Universiteit Utrecht

Designing a virtual environment in VR space using memory enhancement techniques

Introducing a VR approach to GDPR awareness training

Ishdeep Pal Singh Bhandari (ICA-6060927)

Supervised By:

Dr. Joske Houtkamp (UU), Dr. Remco Veltkamp (UU) and Dr. J.W. Bosman (ING)

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Abstract

The introduction of virtual reality (VR) has made it possible to implement memory enhancement techniques such as the method of loci in a virtual setting (virtual memory palace). The studies into the virtual memory palace (VMP) have provided beneficial insight into how the memory palace can be applied to virtual environments (VEs). Moreover, these showcase the improvement in retention of the individuals after using the VMP. This thesis investigates whether a VE inspired by memory enhancement techniques can be used as a learning tool to teach employees at ING about GDPR compliances (specifically data privacy compliances). This study explored which memory enhancement techniques can be applied to the VE and how they affect the memory process. To implement this study, we performed experiments on 23 participants out of which 12 were master students (with no prior knowledge of data privacy compliances) and 11 were ING employees. The experiment involved using the designed VE, performing one test and answering one questionnaire. The test was designed to check whether the participants were able to mark the location of the information found in the VE. The questionnaire was designed to test how the participants applied the information they saw in the VE.

Our results show that both the ING employees and the master students showed similar performance on the second questionnaire and shared similar preference on using the VE as a daily tool for learning. The performance in the first test wasn't 100% conclusive as some participants with low scores in the first questionnaire performed better in the second questionnaire. Using this VE, we were able to teach the participants some data privacy compliances. This thesis lays a foundation for applying VEs inspired by memory enhancement techniques in daily life situations.

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Finally, I must express my very profound gratitude to my parents and to my friends for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them. Thank you.

Contents

List of Abbreviations

GDPR General Data Protection Regulation

VR Virtual Reality

HMD Head Mounted Display

VMP Virtual Memory Palace

VE Virtual Environment

FPS Frames per second

FSM Finite State Machine

DPE Data Protection Executive

DPO Data Protection Officer

BU Business Unit

STM Short-Term Memory

LTM Long-Term Memory

Preface

The thesis, entitled designing a virtual environment in VR space using memory enhancement techniques, has been written to fulfill the graduation requirements of the MSc Game and Media Technology programme at the Utrecht University (UU). It investigates the potential for using the memory palace technique to train ING employees about GDPR compliances specially data privacy compliances. The idea of this research was proposed by Ishdeep Bhandari and Joske Houtkamp to ING where the focus was determined to be finding a new way to teach data privacy compliances to the employees. The main deliverables of this thesis are:

- A scientific thesis, which can be found in beginning of this document.
- An annotated appendix to complement the thesis. The appendix contains:
  - Research Methods used along with the pre-study required.
  - Questionnaires used in the experiment.

Ishdeep Pal Singh Bhandari

Utrecht, 12th September 2019

Chapter 1

Introduction

The art of memory palace [2] (method of loci) is a very famous memory enhancement technique where the user adds information that he/she wants to remember to a mind palace which would be retrieved whenever needed. Being able to virtually implement this technique outside of a person's mind and in a virtual space was made possible by the use of VR. Nowadays, Virtual learning techniques have been applied to employee trainings more and more due to its efficiency in the workplace [6,7]. Moreover, VR environments have proven to be more reliant when it comes to spatial memory tasks as compared to real-life or just desktop examples [3,12,28,29]. Also, research shows that the memory palace technique has proven to be efficient [12,28,29,1] when it comes to retention. The increase in retention is based on utilizing multiple parts of the memory when which involves processing the information in the palace (i.e. levels-of-processing approach [38]) leading to the increased complexity of using the technique [35]. Moreover, the memory palace's technique of associating information to specific locations or objects [38,48]. More information on the previous studies can be found in the related work section.

The memory process (learning and storage) consists of multiple components such as retention, retrieval and expression [10]. Furthermore, some common examples of memory enhancement techniques such as mnemonics, co-relations between memories and locations which were used as a part of this research. This research investigates the use of a virtual environment (VE) in VR using a Head Mounted Display (HMD) designed using some aspects of the memory palace technique and inspired by the workings of the memory process to help employees learn and understand GDPR compliances [4,30], specifically focusing on data privacy compliances [4,5]. The research aims at exploring the use of memory enhancement techniques in a VE (interactive VR environment) to teach the employees at ING about the complainces that exist within the GDPR. Additionally, this research will compare the VE and the already existing ING training exercises on the basis of preference of use. These trainings at ING currently involve training videos, seminars, e-learning etc, which some employees at ING found to be repetitive and uninteresting over time based on the input from the employees.

To implement this research, we introduced an interactive virtual environment (VE) in VR that contained unique and surprising elements. The employees had full control in interacting with the environment. The VE is designed using techniques used when designing a memory palace and also consider the aspects of the memory process. In this study, we evaluate whether the VE could be effectively used as a learning tool. Second, we test if it is possible to teach individuals with no experience with data privacy compliances using the VE. In addition to these findings, we identify and describe potential issues the participants face when learning to use the VE in VR. We also provide suggestions based on our experiences and the responses of the participants during this study.

The contributions of this thesis begin with providing an insight into incorporating memory enhancement techniques into virtual environments by exploring and understanding the workings of the memory process. We also provided a VE which can be used as a learning tool to teach individuals relevant information (in this study, specifically teach the ING employees about data privacy compliances which are a part of the GDPR). Finally, design guidelines that were consolidated from previous works were used to design the VE.

The remainder of the paper is structured as follows: Section 2 discusses the related work. The research questions and approach are discussed in Sections 3 and 4. Section 5 describes the experiment which is followed by Section 6 describing the results. Section 7 and 8 close with the discussion of the results followed by conclusion and ideas for future research.

Chapter 2

Related Work

2.1 Memory Process

The most common use of memory is gaining knowledge or learning and to simplify the notion of learning Bloom created six categories of cognitive skills [40,41] (See figure 2.1) ranging from lower-order skills to higher-order cognitive skills. These skills were formulated after Bloom's introduction of the classification of cognitive skills and each skill has a specific goal towards learning. With the development of these skills many changes were introduced, some being changes to the levels: remember, understand, apply, analyze, evaluate, and create [42]. The revision of these levels introduced four types of knowledge that can be employed by a learning activity: *"factual (terminology and discrete facts); conceptual (categories, theories, principles, and models); procedural (knowledge of a technique, process, or methodology); and meta-cognitive (including self-assessment ability and knowledge of various learning skills and techniques)."* [40,42]. Bloom's taxonomy has its uses in cognitive processing, critical thinking and many training programs.

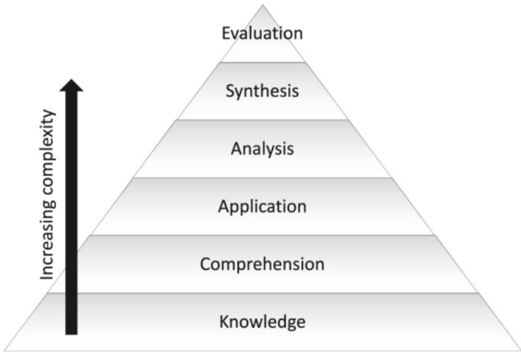

Figure 2.1: Bloom's Taxonomy reprinted from Bloom's taxonomy of cognitive learning objectives. [40]

Now we introduce how the memory process works to support learning by beginning with Short-Term Memory (STM)/Working-Memory. Several models in the past have been developed to explain the process of STM. One of the most used and researched model is the Working-Memory Approach [36] introduced by Baddeley. Baddeley's model distinguished itself from the older models because he proposed that the working memory was made up of different components [38]. As can be noted from the figure 2.2, there are four parts of the model namely: the central executive, the visuospatial sketchpad, the phonological loop and the episodic buffer [37,38].

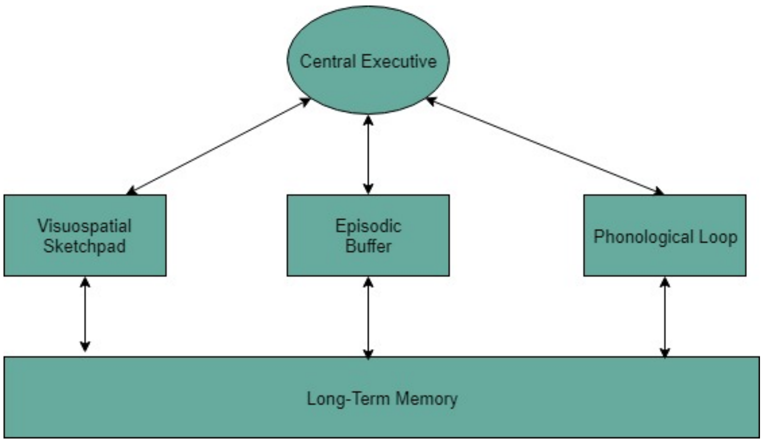

Figure 2.2: Baddeley's Working-Memory Approach: Simplified. [38]

The phonological loop is the part of the model that can process limited number of sounds for a short period of time, process languages and the silent sounds you make while reading [38]. The role of the phonological loop is crucial in working memory [41,38] for example from simple counting task to mathematical calculations or from describing a trip to a friend to learning a new language [38]. A second component of the Baddeley model is the visuospatial sketchpad that is responsible for processing visual and spatial information [38]. It is responsible for helping to navigate from one place to another [38]. Visuospatial sketchpad also stores visual information encoded from verbal information and stores the information of a scene, for instance the relative placement and shapes of the object [38]. In everyday life the visuospatial sketchpad has multiple benefits for example: the visuospatial sketchpad is activated when you try to find a way from one location to another [43,38] and it helps in retaining a brief image of an object that you just saw after closing your eyes [38].

The working-memory model describes the central executive as the process responsible for integrating information from the episodic buffer, visuospatial sketchpad and the long-term memory (LTM) [38]. The central executive is involved in a wide variety of functions, focusing attention, coordinating behaviours, transforming information, suppressing irrelevant information and selecting strategies [37,38]. Another notable feature of the central executive is that, it does not store any information like the other components [38].The central executive plays a crucial role in the overall functioning of working memory. The central executive works like an executive who decides which information deserves more attention, what strategies to use and how to tackle a problem [38]. The fourth component of the working-memory model was the episodic buffer which was added 25 years after the proposition of the original working-memory model [38,44]. The role of the episodic buffer is to temporarily store and combine information from the phonological loop, the visuospatial sketchpad and the long-term memory [38]. Baddeley added the episodic buffer as a part of the working-memory model to help solve the problem with how memory integrates information from different modalities [37,38,44], since the episodic buffer combined the audio, visual and spatial information with the information from LTM [38]. The episodic buffer is a temporary memory system unlike LTM, but it helps to create a richer and more complex representation of an event [38]. One example of episodic buffer can be: an unfortunate incident occurred in your life and you unintentionally said something rude to your friend while talking. Later, you go back to the situation and try to figure out whether your friend was offended. So, you would need to recall the person's verbal response, their facial expression and even information from the long-term memory regarding your friend's behaviour in the past [38].

The working memory/STM has a very limited capacity and any information that is to be stored can be lost within less than a minute [38]. So, for the large storage of information we have the long-term memory (LTM). The LTM contains information from experiences that you have gathered throughout your lifetime- often multiple decades [38]. Matlin [38] talks about three aspects of LTM, namely [38]: encoding- which involves processing and storing the information in memory; retrieval- which is the process of retrieving stored information in memory; and autobiographical memory- which refers to all the experiences that are personal and related to the individual. A very famous encoding technique is called the levels-of-processing approach/depth-of-processing approach that suggests that meaningful process of information leads to better recall than just using sensory processing of information [38]. Generally, you recall better the information that has been processed on a much deeper level [38]. The examination into the research conducted on the levels of processing approach yielded multiple theories that work with the approach. For instance, trying to remember a name of the employer in a job interview, you will try to process by finding something unusual (unique) about it [38]. Another theory is that information is remembered better if you try to relate the information to yourself (Self-reference effect) [38]. For example: people are more inclined to recall words that are related to them rather than the ones that are not [38].

The encoding-specificity principle- suggests that if the context during retrieval and encoding is similar, the recall is better [37,38]. One example was demonstrated by Marian et. al [38,48] where participants fluent in both English and Spanish were told four stories- two in English and two in Spanish. Later, they were asked to answer questions for the stories where some questions for the Spanish and English stories were in English, and some in Spanish. It was found that the participants were relatively more accurate answering questions in the same language as the stories. Emotion (reaction to a specific stimulus) and mood (a general and long-lasting experience) [38] has shown its effects on memory. For instance, Waring & Kensinger [49] conducted an experiment where they showcased photos that corresponded to positive, negative and neutral stimulus. After 10 minutes the participants were given a surprise recognition test where they were asked to recall whether they had seen these photos and the background for each earlier. It turns out that the recall of the negative and positive stimuli photos was very similar and higher than that of the neutral stimulus. However, for the background of each photo, the ones with neutral stimuli were more accurately recalled than the one with the positive and negative stimuli. So, this suggests that when a stimulus is uninteresting the background features tend to be remembered more accurately as people tend to explore more.

Retrieval is followed after encoding, and they go hand in hand [38]. There are different types of retrieval such as: explicit memory task where a researcher explicitly asks you retrieve information for a test that the participant saw earlier and knows that they are being tested [38]; and implicit memory task where the participant is given some information to remember followed by a cognitive test that doesn't directly ask to recall or recognize the previous information [38]. Studies have shown that some adults often cannot remember stimuli when tested on explicit tasks when compared with implicit tasks [38]. Kristin Mitte [38,50] conducted a meta-analysis of low-anxious and high-anxious people for explicit and implicit memory tasks, but they yielded similar results. However, she also mentions that a meta-analysis is not enough to show the difference of performance between low-anxity and high-anxiety people on memory tasks. She suggested that people with anxiety disorders remember threatening stimuli more accurately. The final aspect discussed by Matlin [38] is autobiographical memory. It includes imagery, emotional and verbal information of past events [38,51]. An effect called the flashbulb memory is particularly prominent in autobiographical memory, which refers to the circumstances during which a surprising and emotionally arousing event was recorded in your memory [38]. Talarico & Rubin [38,52] conducted an experiment asking students to describe where they were or what they were doing during the September 11 2001 attacks. It was found that the details became inconsistent after each test session (separated by a few weeks each) but the students remained confident about their details until the end. This shows that certain events can have a major impact on memory and even sometimes trick the mind into believing what they perceive is right.

Another type of memory categorization is spatial memory and can be defined as *"the memory system that encodes, stores, recognizes, embodies, and recalls spatial information about the environment"* [12,14]. Krokos et al. [12] suggests some findings where navigation and memory are linked [19,20]. Furthermore, Madl et al. [14] suggests there are many mechanisms involved when processing spatial information. Krokos et al. [12] also mentions the different cells in the hippo-campus that are responsible for storing and retrieve place-object association information [21,22,23].

The VE used also effects all the memory processes described in the Baddeley's Working Memory Approach model (Fig. 2.2). Since the VE is new to any individual visiting it, certain visual and navigation cues such as special markers, type of the environment, navigation and text, images or number used in the environment trigger the elements of the STM (section 2.1). After using the VE the information processed by the STM gets stored in the LTM. When the VE is recalled again from the LTM to remember the information stored, the elements from the STM process it. The central executive makes the decision based on the information processed by the elements in order to retrieve the required/requested information. The VE uses multiple components of the memory model to retrieve the required information which increases its complexity, leading to better information recall and encoding.

2.2 Memory Palace

Memory enhancement techniques have existed for as long as 400 B.C [2,42], and the most famous of them all is mnemonics [37]. The art of mnemonics is associating different objects or images to preexisting information and recalling them whenever the information was needed. One famous technique is called the memory palace technique (the method of loci) which is based on an ancient Greek memorization technique. It has been in use since about 500 B.C. At that time, this technique was one of the very few ways to store and memorize information externally. This was based on the belief that having an orderly arranged memory is important for having a good memory [2]. The notion of the memory palace as described by an unknown Greek author [2] is imagining a large building (a place or building familiar to the practitioner) while mentally walking through it and placing symbols for items to remember; also associating a behaviour or event (ideally something unconventional) for each symbol placed in the buildings.

Visual aspects or cues have a positive influence on human memory [34]. So, the repeated imagination of the method of loci buildings and walking through these buildings, supports in remembering the items placed in them. Finally, creating a path through the method of loci building helps in structuring the information when it is needed for recall [2]. Remembering the symbols associated with the information in a virtual palace is easier [1,35,26] when compared to just remembering the information. However, this is subjective, since when the human brain is put through more work than just a single task, the information is processed more thoroughly [35]. This is also called the levels of processing approach as described in section 2.1.

To increase the effectiveness of the memory palace and help the user to design it more clearly *Ad Herennium* [2] mentions some design guidelines that are crucial to designing a memory palace. Using a crowded place has a negative effect on impressions [1,2] so it is important to use solitary environments. The distance between each imaginary building must be about 10 metres to avoid overcrowding. A unique sign every fifth loci helps in creating navigation cues to help navigate the memory palace. Avoiding repetitive environments is helpful since it is easier to remember non-uniform setups than uniform setups [1]. The loci shouldn't be too spacious or too narrow. Avoid too brightly lit loci as it affects the retention of the image since it starts to shine or dazzle [1]. Also, avoid too dark loci as shadows can overshadow the information to be remembered in the environment [1]. These guidelines can be summarized as follows [1]:

- The space should be solitary and not very crowded.
- Distance between loci should be at-least 10 meters.
- Having a unique sign every fifth loci.
- Avoid repetitive environments.
- The loci in a neither too spacious nor too narrow.
- The loci is not lighted too dark or too bright.

These guidelines help in creating a more elaborate structure of the memory palace which helps in retention of the information.

2.3 Memory Palace in VR

There have been prior implementations of the memory palace in a virtual environment known as the virtual memory palace (VMP). This technique in desktop environments has shown its effectiveness when compared with a personal mental environment visualization [15,1]. Fassbender and Heiden [1] showed that remembering a list of words by associating different loci for each in a VMP, was more efficient than just trying to remember them in a span of 2-3 minutes. Legge et. al. [15] used 3 conditions to test the memorization of 10-11 uncorrelated words; (a) where participants were given a 3D graphical environment to use, (b) where participants where asked to imagine a scene in their mind (c) where participants used personal mnemonic techniques. The results showed that the group with the first condition performed better than the other two conditions.

Although the research into the VMP in VR has been not very prominent, the results derived from these researches show potential uses for these techniques [1,12]. The VMP technique involves implementing the method of loci technique in a virtual environment. The VMP has proven to be beneficial in aiding immersion and recall [12], therefore, leading to retention [11]. It is important to know that these studies have only focused on retention of words and not on any other type of information. So, the results from these studies can be subjective since multiple information examples must be considered to see the effect of the VMP technique. Furthermore, the task of remembering a set of words when compared to traversing a 3D environment are very different situations. Studies [36,45] have shown that as the processing of information increases, so does the retention. The studies into VMP suggest that using memory enhancement techniques have a positive impact on retention.

Employee training in virtual environments is a new area and building collaborative team building exercises in VR or normal desktop environments have been developing rapidly [16]. Campbell and Kuncel [17] have provided a list of capabilities that might be taught in training exercises, namely: observable skills, knowledge, attitudes and problem solving skills [13]. The training exercises mentioned in these studies correspond to company trainings for office jobs where employees work in teams and must have the necessary knowledge required to perform their tasks. However, even with these benefits, it is still unclear what design principles such as content presentation, interface, embedding in an application for learning, context should be used to get the best outcome from the trainings. The learners must not be overburdened with learning goals as it may lead to demotivation [18]. These above studies enabled us to justify the use of a VR environment as a teaching example.

Wouters et. al. [39] mentions the use of instructional techniques (see table 2.1) increase learning and motivation while developing serious games when compared to serious games with no instructional techniques. Their study used meta-analysis to describe how much of an effect these different techniques have on motivation and learning. The main criteria for the searches were to gather studies where the groups (with a sufficient sample size) had been compared with and without using the instructional techniques. The studies referred for the analysis involved serious games, virtual environments, type of instructional technique, types of cognitive processes, motivation and visual design. Additionally, their study mentions the performance of the instructional techniques on learning and motivation.

Instructional technique	Examples	Cognitive processes	Motivation
Adaptivity/Assessment			
Adapting complexity/difficulty of game tasks to the abilities of the student through real-time assessment	Adaptivity	Selection Organization/ Integration	No
Advice			
System generated information to support the learner to continue in the game (e.g. by focusing attention).	All types of advice whether contextualized, adaptive or not	Selection	No
Collaboration			
Working in groups with discussion, often aiming at the explication of implicit knowledge	Players played in dyads, groups or engaged in group discussion	Organization/ Integration	No
Content Integration			
Learning content is integrated with game mechanics	Intrinsic integration	Selection Organization/ Integration	Yes
Context Integration			
The combination of a serious game with other instruction methods (e.g. a class discussion)		Selection Organization/ Integration	No
Feedback			
Information is given whether an answer or action is correct or not. The feedback can be corrective (correct or not), explanatory (why correct or not).	Feedback, Guidance	Selection	No
Interactivity			
Learners make choices in the game in order to solve a problem or to perform a task	Interactivity, learner control and choice of game features	Organization/ Integration	Yes
Level of Realism			
The use of both the auditory channel (e.g., spoken text, sounds, music) and the visual channel. Also the type of auditory and visual representation.	Modality, Sounds, Music, Visual design	Selection	Yes
Modeling			
An explication or indication how to solve a problem. The explanation can be given by a peer or expert and can be verbal, animated or graphical.	Different types of scaffolding, modeling, worked examples	Selection Organization/ Integration	No
Narrative elements			
A narrative context or manipulation of narrative elements which provide a cognitive framework	Fantasy, rich narrative, foreshadowing, surprising events, curiosity	Selection Organization/ Integration	Yes
Personalization			
Ideas, characters, topics and messages are presented in such a way that they have a specific high interest value for the learner/player	Personalization, Personalized messages	Unknown	Yes
Reflection			
Learners are stimulated to think about their answers and (sometimes) explain it to themselves	Reflection, self-explanation, elaboration, collaboration, worked example	Organization/ Integration	No

Table 2.1: Overview of instructional techniques, examples of the technique, the associated cognitive processes and the motivational characteristic. Reprinted from Wouters et. al. [39]

2.4 Search and Interaction aid Recall

Krokos et al. [12] conducted an experiment using the VMP technique where they tested the recall of faces (images of faces located at different locations in the environment) of famous figures or iconic characters in two different conditions (HMD and desktop). From the study it was concluded that the use of HMDs helped recall when compared with regular desktop variants. These examples include comparing the difference between if a target is present in the environment or not [24]; subsequently, the navigation times and extra time spent traversing the environment were tested for a virtual environment [25] and finally recalling tasks performed after boarding an airplane in a virtual airport [29]. In all these examples, the HMD had clearly better overall results. Mania et al. [26] showed that by using an example of a virtual airport the results were better in the HMD than in desktop condition. However, after one week from the experiment the recall results dropped consistently across all conditions.

Studies on VMPS using HMDs have shown the connection between navigation, interaction and recall. Brooks [27] studied that the participants in the active condition (controlled their movement in the VE using a joystick) traversing a 3D virtual house had better recall than the participants in the passive condition (watching the progress of the active participants). Perrault et al. [28] had shown the use of the method of loci technique using Kinect by creating two conditions, where the participant had to associate object with hand gestures based on commands shown on the screen. The study revealed that the participants recalled better when pointing to objects that they wanted to relate in the environment when compared with a simple 2-segment marking menu gesture (a gesture technique to interact with Kinect).

The VE designed for this study was built using the following design principles:

- The VE includes elements such as placing information at a specific location in an environment (derived from the technique of memory palace) and surprising (and unusual) elements. All of these elements have proven to have a positive impact on retention of information.

- The location of the guidelines in the VE and the design of the VE were inspired by the *Ad herennium*[2] guidelines because of its effectiveness in the memory palace technique.

- The VE used was not designed as a game but as an interactive environment with some game elements. So, it was important to understand and incorporate the use of different techniques in enhancing learning and engagement in serious games as described by Wouters et. al. [39]

- Some game elements used in the VE design were collectibles and free flow movement.

- Some navigational techniques were used in designing the VE to help the users in navigating an unknown environment. One was the landmark technique (urban environment cue) [45] that helps in providing the participant with a sense of orientation and direction in the environment. Another was trailblazing navigation technique (breadcrumb markers) [45] which allows to spread the markers in way as to remember the path that was already visited.

- The VE also used 3-D sound to provide situation awareness [44] and immersion into the environment.

It is important to note that the VE designed in this study is not a VMP but only incorporates some elements of the memory palace technique as described above.

Chapter 3

Research question

In the previous studies, VMP showed its effectiveness and potential in teaching information. In our study, we create a VE where the design is inspired by using the technique of correlating information to locations as used in a memory palace and by including certain aspects about the memory process (surprising elements, motivational elements and complex design). We test whether that VE could be used as a learning tool in a real life situation (teaching relevant information to ING employees).

Research Question - Can a virtual environment (VE) where the design is inspired by the memory palace technique and the memory process be used as a learning tool? (exercises involving teaching about GDPR compliances specifically data privacy compliances)

Hypothesis - We expect that the techniques used to design the VE would help in teaching the data privacy compliances to the ING employees and also to the individuals who have no prior knowledge of data privacy compliances. This is possible by using a unique design of the environment, easy to understand versions of the data privacy compliances and memory enhancement cues.

Chapter 4

Approach

Using the findings from the literature study of the VMP, memory process and the memory palace a research question is devised (Section 3) to supplement this research. The goal of this study is to answer the research question mentioned above. Additionally, it will be used to help employees (working at the DPE office See figure C.2) at ING to understand and remember the data privacy compliances from the set of the new GDPR compliances introduced in 2018. The design of the VE was inspired by using techniques such as co-relation between text and locations in a VE, adding motivational and educational elements and using memory-enhancement cues. The amount of information stored in the VE that is recalled by the participants after using it will be tested. The participant's performance after using the VE and the preference of using it as a learning tool will help in determining whether the VE is an effective learning tool. The information to be used in the VE and recalled (or learnt) will be a compressed version of the GDPR data privacy compliances. In order to supplement these answers some tasks needed to be performed.

The first task is to understand what GDPR is, how it is implemented at ING, how the employees work with these compliances and what sort of training exercises are already in use at ING (See Appendix C). The second task is to find a method by which the employees could be trained for these compliances in an interactive and fun way. The studies found during the literature study have shown that the VMP technique can be used as a tool in memory enhancement and teaching exercises. This study uses the technique of co-relating between objects in an environment from the memory palace technique to help in the retention and understanding of the GDPR compliances. It is important to note that the information (to be taught using the VE) that is used in this study is not actual GDPR compliances. Instead, they are 10 guidelines derived from preexisting and newly introduced data privacy compliances formulated under the guidance of an employee at ING.

The employee is responsible for deconstructing data privacy compliances and creating the internal ING training exercises.

This study tests the effectiveness of the VE in training the employees with the guidelines. In order to do so, research is conducted using principles from psychology literature on how the memory process works, how learning is achieved and effective ways of enhancing learning. Bloom's taxonomy comprises of 6 levels of cognitive skills (as previously shown in Figure 2.1). This study includes 4 of the 6 levels mentioned: Comprehension, Application, Analysis and Synthesis. Since the information to be remembered is in the form of guidelines, the participants have to try and remember what information the guidelines are trying to communicate (Comprehension). The Application of these guidelines is achieved by answering the final questionnaire containing questions relating to these guidelines. The Analysis and Synthesis skills refer to how the participants use the information gathered in the VE to answer the final questionnaire. This is because the final questionnaire will consist of questions that invoke critical thinking in the participant to apply the guidelines.

The third task implements the VE to train the employees. Based on the previous studies mentioned in section 2.3 the VMP performs best when there is full immersion, i.e. in VR. The first step in implementation is designing an environment that is used for the experiment. The environment is designed using preexisting cartoon style assets that are available in the Unreal Engine public repository. The environment consists of some game elements such as collectibles and free flow movement. This environment is finalized after multiple stages of prototyping and evaluation. The design of the environment is guided using the guidelines mentioned in *Ad Herennium* [2] so as to keep the environment close to a proper memory palace. The second step is to design the experiment for the participants. The participants consist of people that are already familiar with the data privacy compliances (Group 1 i.e. ING employees) and people that have no experience with the same (Group 2 i.e. the control group). The third step is to test the environment with the participants. The participants are briefed on what is the goal of this test along with some practice runs on the VR equipment to make the participants familiar with using VR. The participants are also instructed to use the environment to explore and remember the devised data privacy guidelines attached to specific numbered checkpoints in the environment. This test is done in 20 minutes for each participant where the participant try to memorize the 10 guidelines placed in the environment. This is followed by an environment recall test (Appendix D.1) where the participant marked on an outline of the map where he/she found each checkpoint. This allows us to determine how many guidelines they were able to recall after using the VE. The experiment design is kept similar for group 1 and group 2 to avoid discrepancies. The last step of the implementation is to ask participants to rate the experience of using the environment when compared to the traditional training methods. The final task is to consolidate the results gathered in the study and discuss the findings for future research.

Chapter 5

Experiment

5.1 Questionnaires and Tests used

The first test (Appendix D.1) after using the VE is to check whether how much each participant remembers the environment . So, each participant mark where they saw each of the 10 guidelines on an outline of the map. The second test is a multiple choice questionnaire (Appendix D.2) on data privacy compliances which are based on the guidelines used in the experiment.

5.2 Materials and Implementation

5.2.1 Hardware

The hardware consisted of an HTC-Vive Pro (VR Kit) with one X-box one controller, two base station, a Head Mounted Display (HMD) and built-in HMD headphoe for the sound. The base stations were placed diagonally to create a standing only setup. The laptop used to operate the HTC-Vive was a MSI GE63VR 7RF Raider with an Intel Core i7-7700HQ processor and NVIDIA GeForce 1070 GTX graphics card. The HTC-Vive was used in "Extended Mode", with where the HMD showed the VR environment and the screen where the view of the participants were visible. This allowed the experimenter to follow and manage the experiment. Finally, a simple camera phone was used to record parts of the experiment for images and future references.

5.2.2 Software

The software used for developing the interactive environment was Unreal Engine (4.18.2). The main reason for using Unreal Engine was for its foremost support and ease of using

VR. Unreal Engine is known for its leading rendering capabilities which makes it a good choice for VR, since it reduces the screen-tearing of the scene. This allows for a smoother game-play and faster FPS [9] in VR which are few of the factors to avoid motion sickness [8]. The game-play design was done using the Unreal engine's pre-built Finite State Machine (FSM). The environment design is inspired by using the Lowpoly Tropical Island created by Brainbox assets. Finally, steamVR was used to connect and use HTC-Vive with the unreal engine game.

5.2.3 The Derived Guidelines

Before designing the environment, 10 guidelines are derived from GDPR compliances were devised, which were used in the environment. After extensive consultation with an employee at ING who deals with understanding and breaking down new compliances, we devised 10 guidelines based on data privacy compliances mentioned in GDPR. These guidelines were used in the final experiment and added to the VE to help participants read them and recall them after using the VMP. These guidelines were as follows:-

1. Personal data means: any information relating to an identified or identifiable natural individual. Sharing personal data of a customer can only be done in case of a legitimate business reason.

2. ING shall only collect, use or otherwise Process Personal Data, if the Processing falls within the scope of one (or more) of the legitimate Business Purpose : Some of ING's legitimate business purposes are:

    - Performing agreements
    - Safety and security

3. Sometimes it is possible to use the personal data for secondary business purposes. For example:

    - For statistical research
    - For internal audits
    - For legal and business consulting

4. Irreversibly and effectively anonymized data is not 'personal data' and the data protection principles do not have to be complied with in respect of such data. Pseudonymized (encrypted anonymized) data remains personal data.

5. The protection of personal data is also about protecting it from unauthorized loss, alteration, disclosure or access. Data breaches can be fatal to the company and result in losses. For special data breach situations contact the DPO.

6. Every Individual has the right to request an overview of his Personal Data Processed by or on behalf of ING.

7. ING shall Process Sensitive Data only to the extent necessary to serve the applicable legitimate purposes. Some examples:

   - Political opinions
   - Criminal records
   - Sexual orientation
   - Social security number
   - Or any other data defined as sensitive by local law

8. Whenever you want to process personal data, think about what it is for, and if you need to take additional measures beforehand.

9. All personal data that ING collects, stores and processes must be correct and up-to-date at any time.

10. ING shall only retain personal data for the period required to serve the applicable purposes, or for legal reasons.

5.2.4 Environment

The environment that is used for the experiment was designed from scratch using pre-built assets (Lowpoly Tropical Island created by Brainbox) in Unreal engine. The initial idea of the environment design was to create a close to real-life environment which was familiar to all the participants. But after further research into the memory process, the design of the environment was shifted to a more animated (cartoonist) outlook. The reason being that memory is subjected to retain more information about surprising or unfamiliar situations (See section 2.1). The new design of the environment consisted of creating floating islands (See figure 5.1) with each island (checkpoint) having its own unique representation where each island corresponded to a guideline. But, due to navigational and design issues that design was removed. Due to the floating islands and bridges whenever the player looked down he/she immediately felt motion sick due to the heights. The floating islands when connected weren't able to maintain an effective route leading to longer exploration times. Even if the player managed to successfully traverse the environment, he/she still found themselves less immersed due to the floating design of the environment. This led to the creation of the final environment which was designed with multiple layers using the guidelines as interpreted in *Ad Herennium* [2].

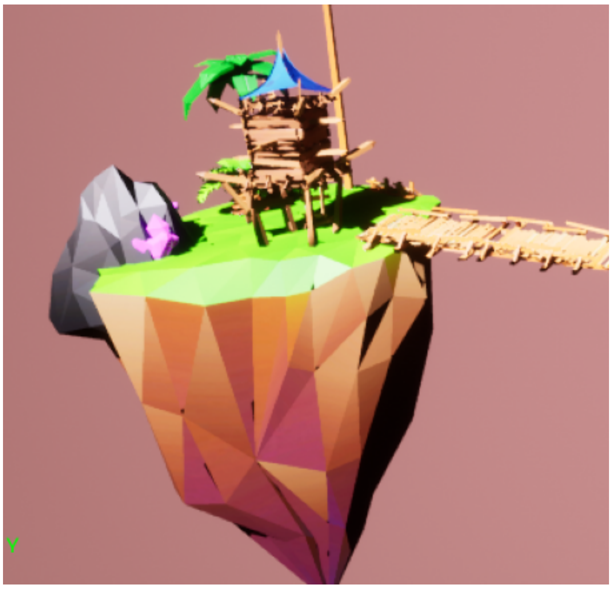

Figure 5.1: First Prototype Environment Example i.e. the floating island approach

Figure 5.2: Example Watchtowers

Figure 5.3: Example Houses

The design of the final environment was landmark driven to support navigation [46] for the participant. The landmarks such as watchtowers (See Figure 5.2), houses (See Figure 5.3), trees (See Figure 5.4) and a cave system (See Figures 5.5,5.6) provide uniqueness and diversity to the environment. So, the environment (See figures 5.7,5.8,5.9) is designed as an island. The caves are added to provide an impression of an extra layer to the environment to represent the concept of creating multiple levels in a memory palace. The environment consists of 10 checkpoints (See figure 5.6) where each of the guidelines are displayed. These checkpoints are varied from a small hill to a room in a cave. Each checkpoint has a guideline (with its corresponding number) floating on top of it. This allows the guideline to be visible even from farther away. This represents attaching useful information to specific loci in the memory palace [2].

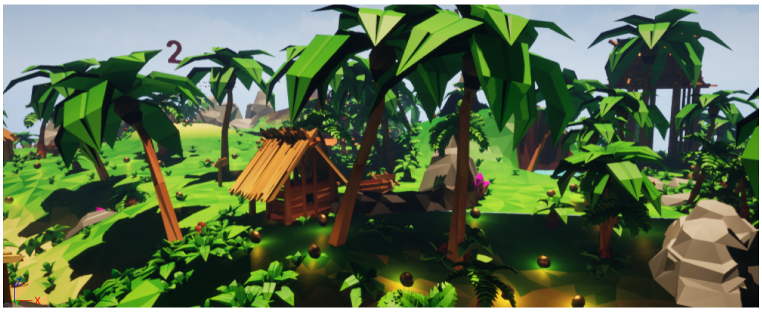

Figure 5.4: Example of the foliage used

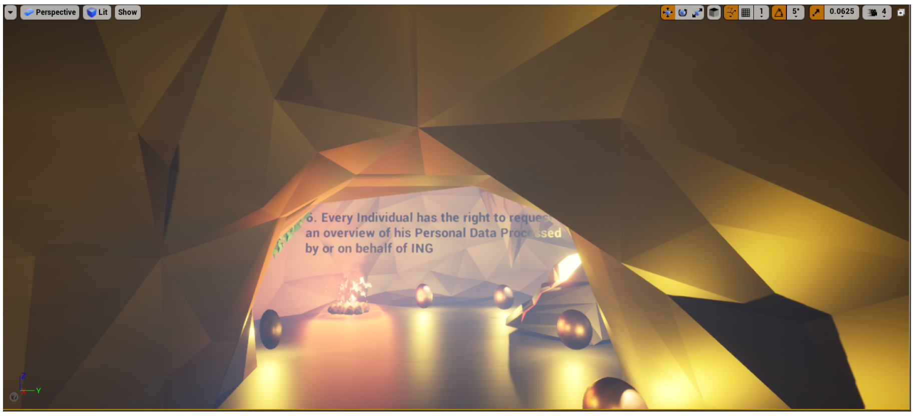

Figure 5.5: Cave room sample design - 1

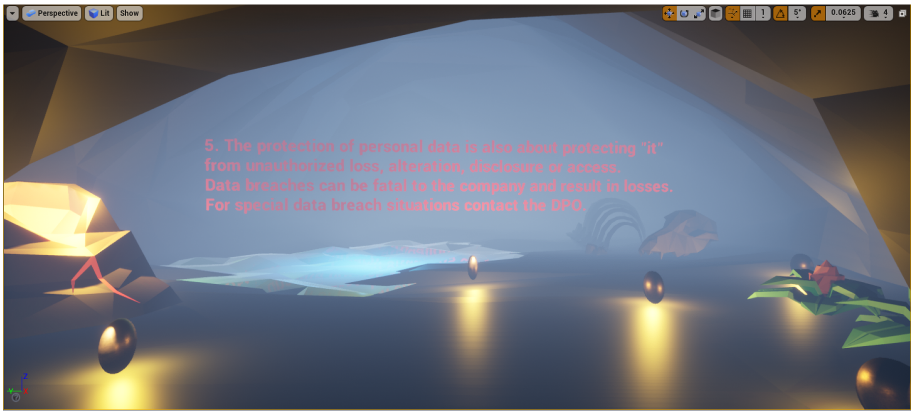

Figure 5.6: Cave room sample design - 2 (Example of a checkpoint in the environment)

Each guideline had a different color to contrast the surrounding checkpoint and big text to help readability. The 3-D sound [44] used in the environment is that of a beach consisting of wind flow and bird sounds. Directional arrows (pointing to checkpoints and the caves) and collectible coins spread across the environment (See figures 5.10, 5.11). The directional arrows are a type of the landmark technique (urban environment cue) [45] and the collectible coins represent the trailblazing navigation technique (breadcrumb markers) [45]. These techniques were mentioned under the design principles in chapter 2. The coins are spread to guide the participant to each checkpoint whilst showcasing the whole environment.

Figure 5.7: Environment Overview - 1

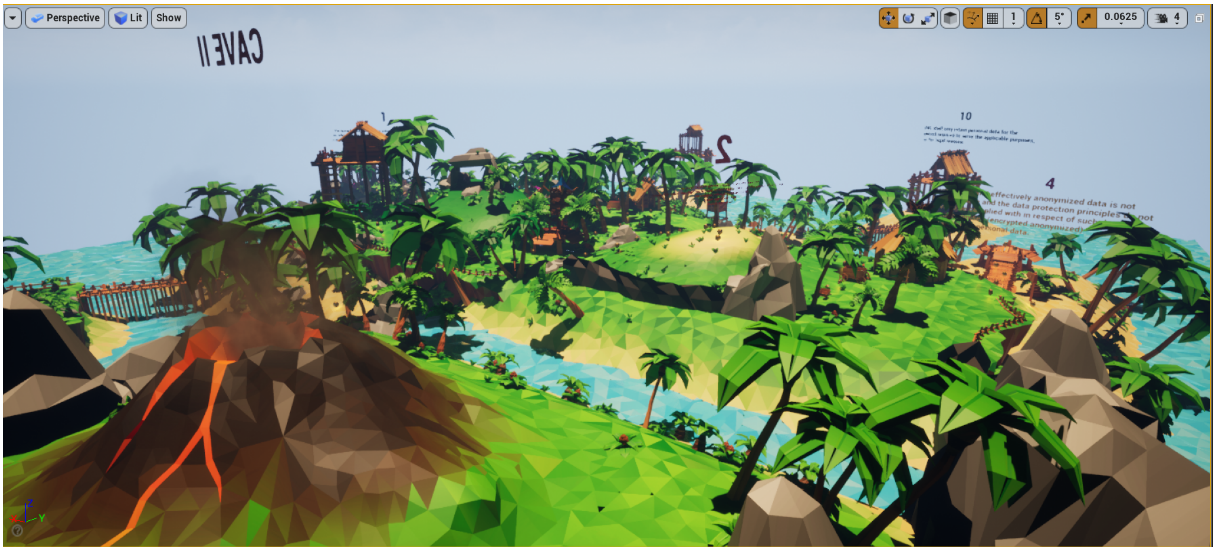

Figure 5.8: Environment Overview - 2

Figure 5.9: Environment Overview - 3

To introduce motivation and educational factors, some of the instructional and motivational techniques mentioned in table 2.1 are applied in this environment. Content integration here refers to the information mapped at the checkpoints in the environment which the participant read and remember. Interactivity in the environment is when the participant explores the environment and visits all the 10 checkpoints by means of controller movement and collecting as many coins as possible. The beach sounds used in the environment and the VR movement provide a level of realism to the environment. Each participant had the freedom to explore the environment, navigate to the checkpoints in an order they felt like and collect as many coins as they felt like which introduced a sense of personalization to the environment. Lastly, since no other information except the guidelines in the environment were provided to the participants, they had to think and explain the guidelines to themselves (reflection).

Figure 5.10: Coins design

Figure 5.11: Directional arrows design

5.3 Participants

The participants were divided into two groups; group 1 (14 participants) included the employees at ING that work with GDPR compliances on a daily basis and group 2 (13 participants) consisted of participants (Master students studying at Utrecht University) who had no prior knowledge of GDPR compliances. The participants had no prior knowledge of the experiment, they participated voluntarily and signed a consent form before the start of the experiment. The division of the groups was based solely on the knowledge of the participants with GDPR compliances. The reason for dividing the groups was that group 2 was used as a control group in determining the usefulness of using the VE as a learning tool. Two participants from each group were unable to complete the walk-through of the environment in VR because they experienced motion sickness within 1 minute of starting the walk-through. Those 4 participants' data was not used for the final results. In some results all the participants were divided into different age groups to showcase performance differences (See Table 5.1)

Ages	No. of ING Employees	No. of Students
21-30	2	12
31-40	3	-
41-50	3	-
51-60	3	-

Table 5.1: Participant Breakdown of 23 participants

5.4 Setup and Procedure

The whole experiment ran over the course of 4 weeks. It started with contacting ING employees by email who wanted to join the experiment for group 1. They were scheduled over the first two weeks. The next week was dedicated to collect participants for group 2. They were scheduled for the last week for the test sessions. The duration of each individual test session was 45 minutes.

5.4.1 Test sessions

During the test sessions, the participants were asked to fill out the consent form and received information about the experiment. At the beginning of the session, extensive instructions on the VR controls and the navigation using the X-box controller (X-box controller controls: Left stick for movement, Button-A for jump, D-pad button down for crouch, D-pad button up for flashlight in case of reduced visibility in the caves) were provided. Each participant navigated the environment using only the X-box controller while viewing it using the HMD and the headphones for the sound. Every participant started at the same location in the environment. Once in the environment each participant had 20 minutes to traverse and familiarize themselves with the whole environment. Additionally, memorize the locations of the guidelines placed at the checkpoints. They could also use the collectible coins and navigational arrows placed in the environment if needed. After completing the environment task each participant solved a simple Sudoku puzzle for 5 minutes to use as a distraction. The results of the Sudoku puzzle was not be of any relation to the experiment. Following this, the participant marked the numbers for the guidelines on an outline of the map from the starting positions. This was followed up by the final test questionnaire (Appendix D.2) where the participant used the information seen in the environment to answer the questions. Both the groups of participants were given the exact same procedure to avoid any bias in the final results. After the experiment was over each participant from group 1 was asked to rate their current data privacy training exercises and the VE they just used based on preference of using it as a learning tool from 1 to 10 (least preferable to most preferable). Every participant from group 2 was just asked to rate the VE based on preference to use as a learning tool with the same scale.

5.4.2 Gathering Results

After all the test sessions are concluded the data gathered was consolidated in an Excel file to conduct statistical analysis. The environment recall scores helped in determining how much information each participant was able to remember from the environment. The rating gathered from both the groups was compared to showcase the preference of the VE as a learning tool. The scores gathered from the final questionnaire suggested how effective the VE was at providing information. These scores were compared with the environment recall scores to test how many guidelines each participant was able to remember and how it affected their final questionnaire scores. The analysis methods that were used are T-confidence intervals, Paired T and 2-sample T to showcase the similarity and difference between the scores.

To provide a robust outlook of the results of this study, different statistical analysis were conducted to answer the research questions. The figure 5.12 below provides an overview of the techniques used to design the experiment and the results gathered from the experiment. Also, which of these results helped in answering the research question.

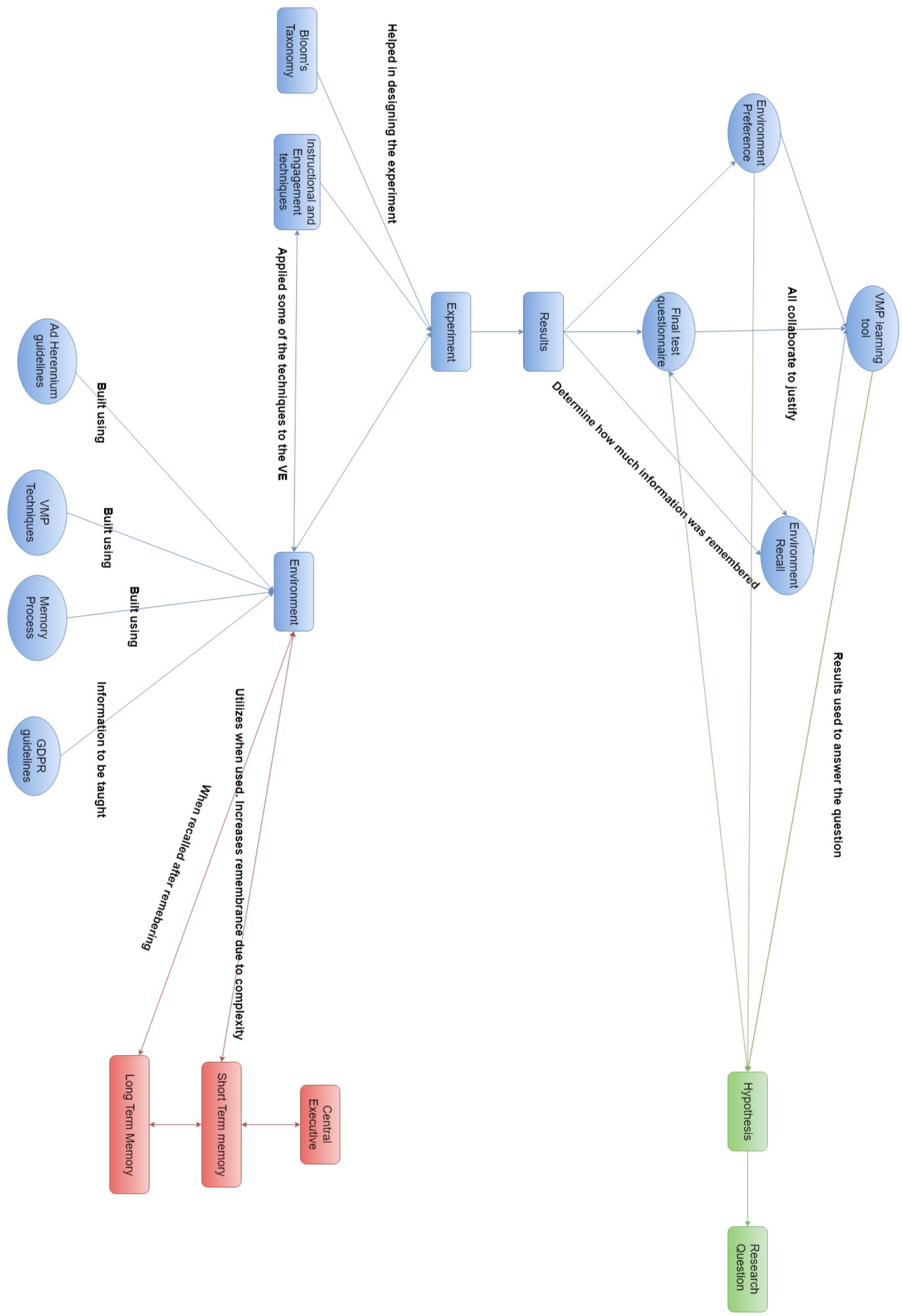

Figure 5.12: Overview of the study and the results

Chapter 6

Results

6.1 Environment Recall Scores

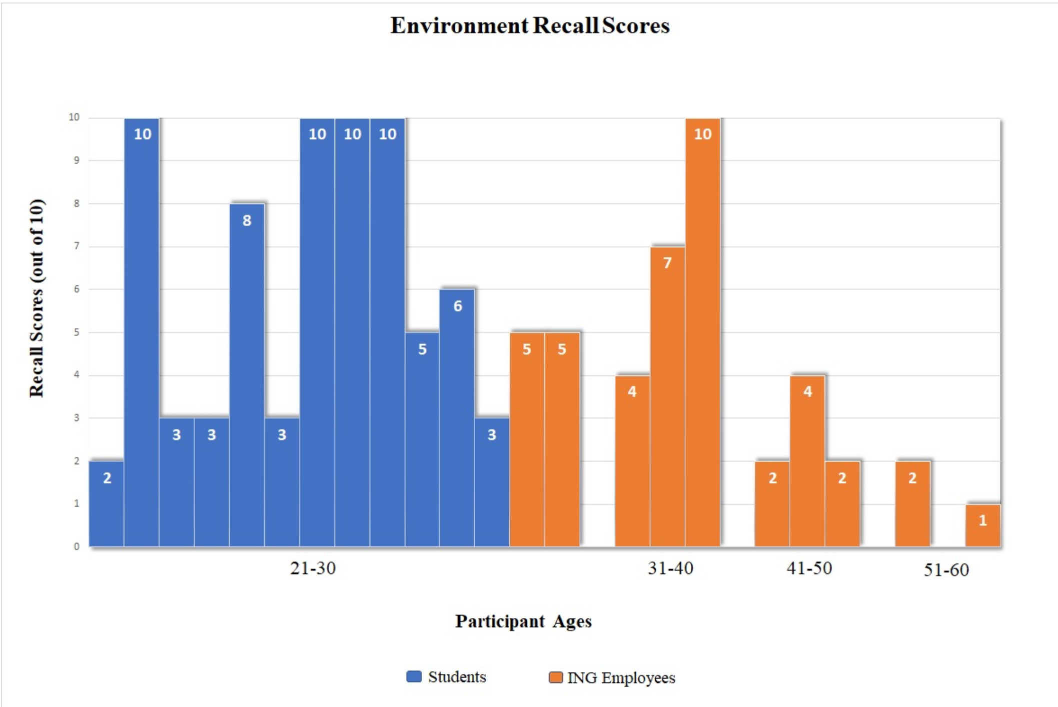

Figure 6.1: Environment Recall scores for individual participants

In order to provide a first overview of the participants' performances, we grouped them based on age groups (See Figure 6.5) namely: 21-30, 31-40, 41-50, 51-60. Here the participants from the age groups of 21-30 and 31-40 appear to have overall higher scores than the remaining age groups, with some exceptions to poor environment recall scores in 21-30. The mean scores of all the participants (See figure 6.6) were also calculated and showcased using a confidence interval of 95%. Using a 2-sample T test we were able to show that $t(21) = 1.755$, $p > 0.05$ at confidence interval of 81% the environment recall scores of the students were greater than that of the ING employees. The use of age groups here was due to an observed trend of decreasing performance with increase in age for the environment recall test.

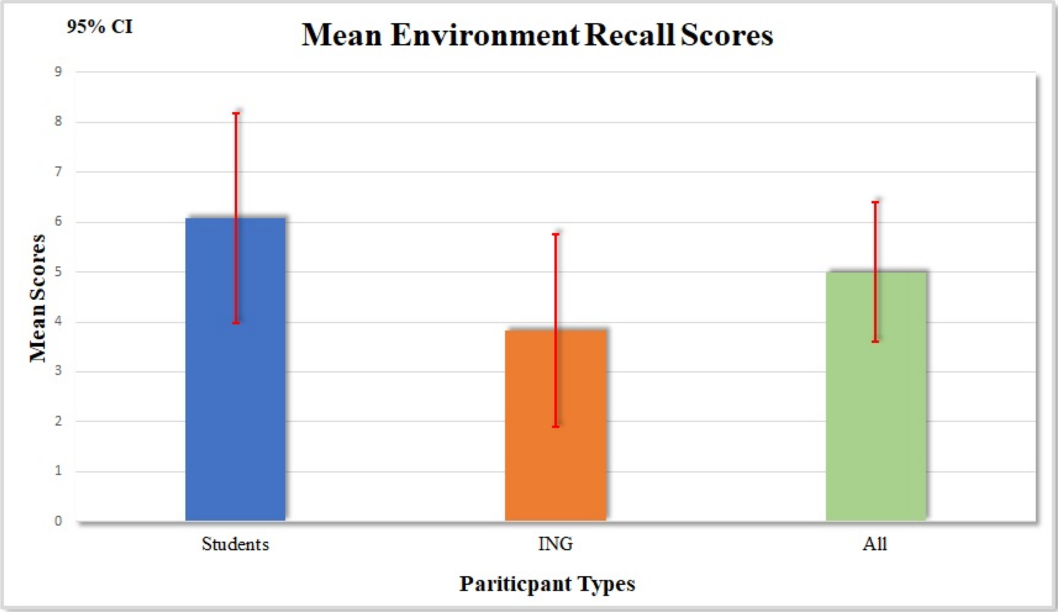

Figure 6.2: Mean Environment Recall scores for all participants

6.2 Final Questionnaire Results

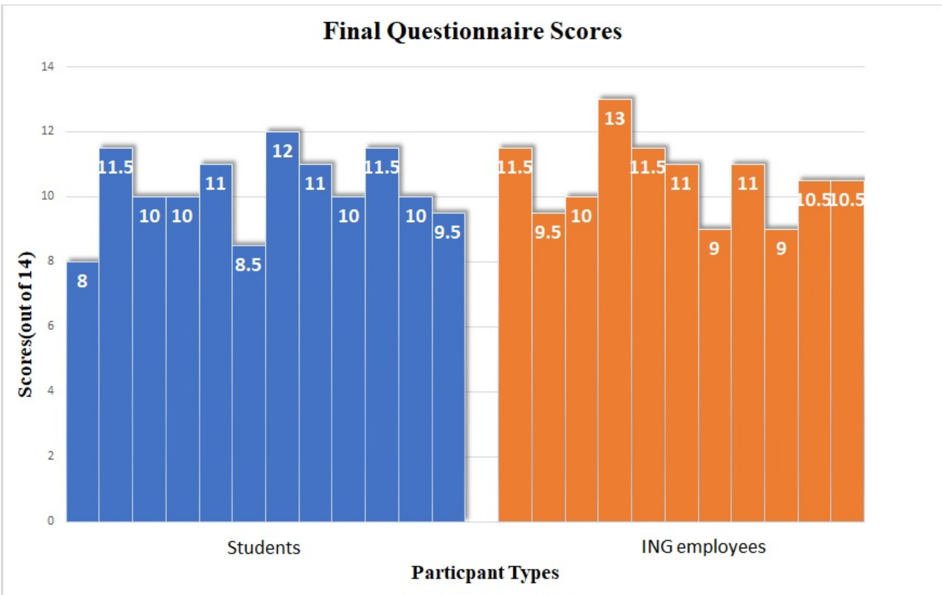

Figure 6.3: Final questionnaire scores for all participants segregated by type of participants

The scores for the final questions were showcased based on the type of the participants i.e. the 2 groups used for the experiment. This was done to show the difference between the results of the two groups (See figure 6.9). We conducted a 2-sample T test on the mean final questionnaire scores (See figure 6.10) of the students and ING employees. We got $t(21) = 0.675$, $p \gg 0.05$ which showed that the final questionnaire scores of the students and ING employees were greatly similar.

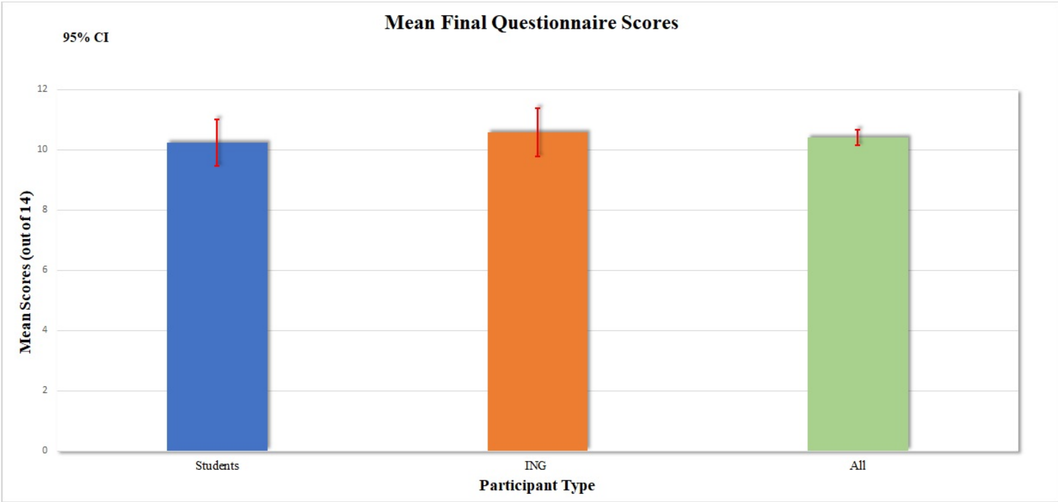

Figure 6.4: Mean Final questionnaire scores for all participants segregated by type of participants

6.3 Recalling information to answer final questionnaire

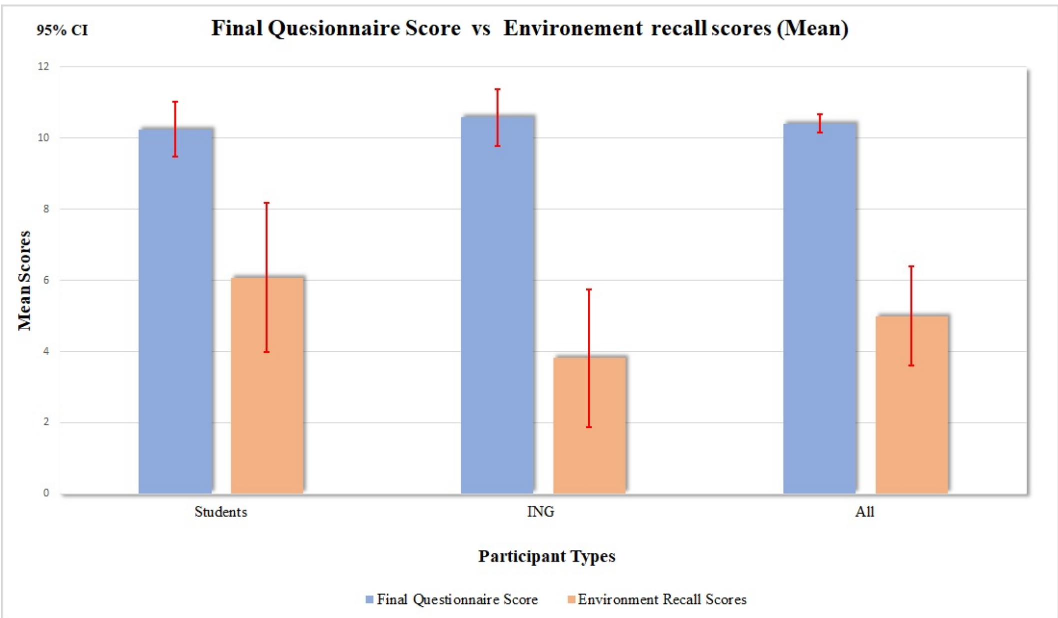

Figure 6.5: Mean Final questionnaire scores VS Environment recall scores for all participants segregated by type of participants

The overall performance of the students in the final questionnaire (10.25 out of a possible 14) were comparable to mean environment recall score of 6 out of 10. The same could not be said about the ING employees as their mean final questionnaire scores of 10.59 out of 14 could not be validated by the low mean environment recall score of about 4.

6.4 Environment Preference rating

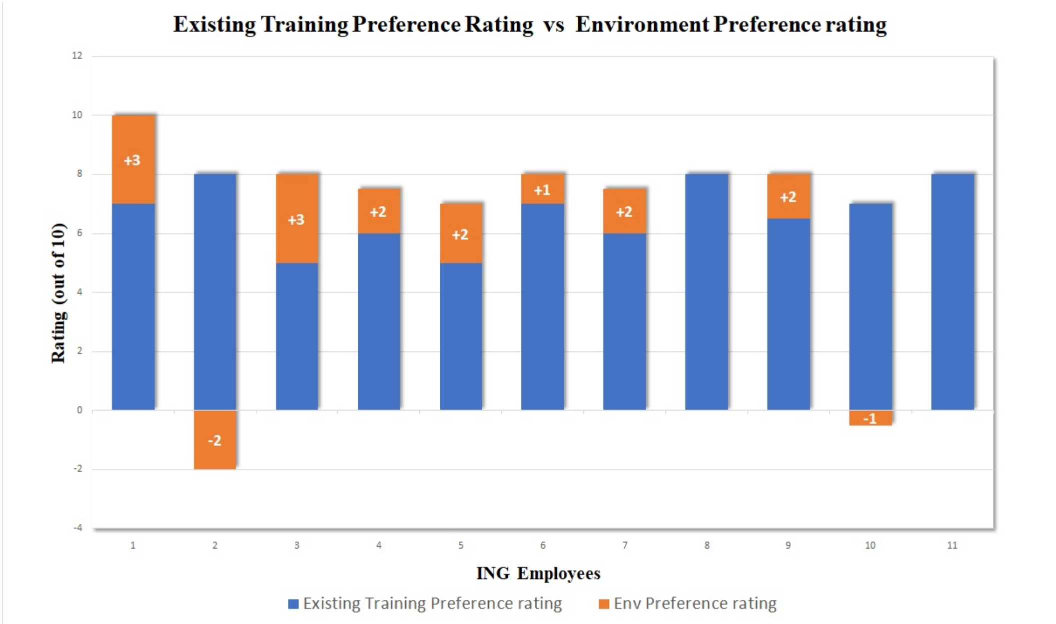

Figure 6.6: Individual environment preference ratings VS existing training exercises preference for ING employees

We first tested whether the ING employees would prefer the VE to learn and compared it with their preference of the currently existing training exercises that teach about data privacy compliances (See Figure 6.12). We conducted a paired T test on these values and got results of $t(22) = 4.65$ and $p \ll 0.05$. This showed that the preference of using the VE was significantly more than that of the preference for using existing training exercises for learning data privacy compliance.

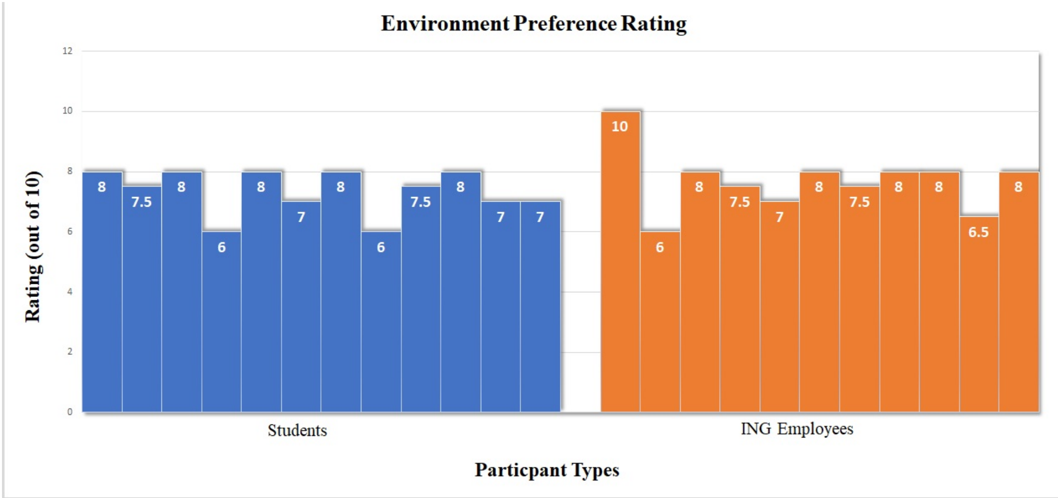

Figure 6.7: Individual VE preference ratings segregated by the type of participants

We also tested the environment preference ratings of the students and compared them to that of the ING employees (See Figure 6.13). We conducted a 2-sample t test on the mean scores (See Figure 6.14) of the environment preference ratings. We got results where $t(21) = 0.92$ and $p \gg 0.05$. This showed that the environment preference ratings of both the students and ING employees were significantly similar.

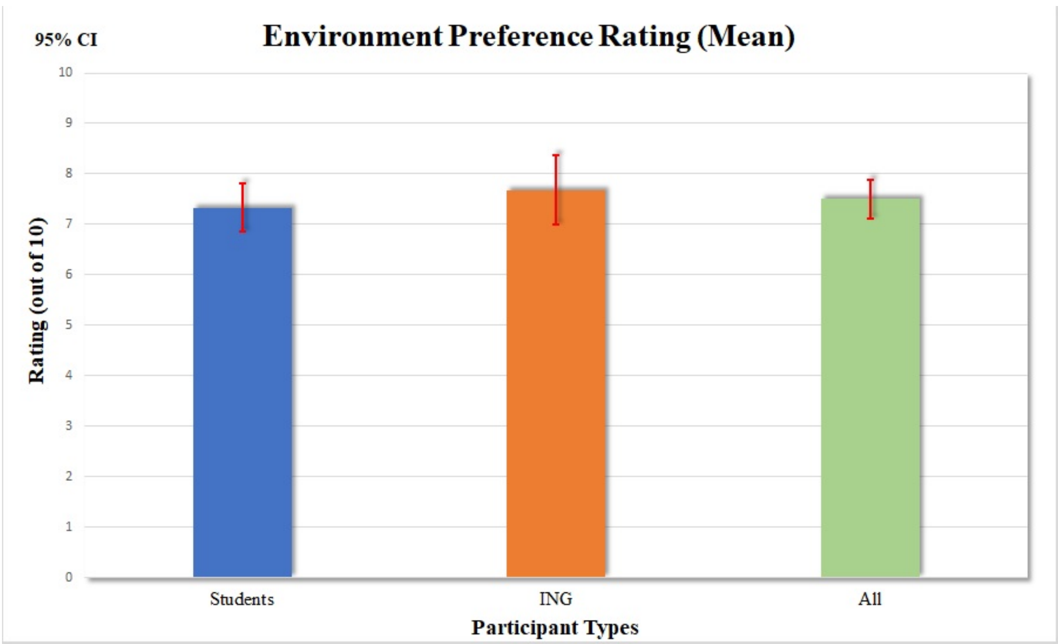

Figure 6.8: Mean VE preference ratings segregated by the type of participants

6.5 Participant discussion

After completing the experiment we asked each participant to share their experience on using the VE. After discussing with the ING employees we found that the VE at times can be quite immersive and one of the participant felt displaced in the real world after using the VE. Another aspect of the VE was discussed that it took time to get used to the environment suggesting maybe 20 minutes was not enough to remember the environment and may require additional sessions. Ten out of eleven ING employees felt that the VE was interactive and immersive which was far better than scrolling through a PowerPoint. Also, getting tested on the guidelines used in the VE was something that employees wanted more of when learning compliances as it keeps them sharp. Lastly, it was discussed that setting up and using a VE was cumbersome when compared to e-learnings as the VE approach is not very flexible due to the equipment and location needed to support it.

The discussions with the students resulted in interesting findings as well. Most students suggested that the environment designed helped them in remembering the guidelines more clearly. The VE was "fun" and motivating to explore due to its unusual nature. They felt that using the VE helped them remember the information more easily. Two out twelve students felt that the VE was too immersive, and they needed time to adjust to reality. One of the students felt that the environment and the information weren't linked and felt that the information wasn't relevant to them. Lastly, one of the students felt that they needed more time to explore the environment and found the colors used in the environment to be distracting.

Chapter 7

Discussion

Our research was aimed at investigating the use of the VE (inspired by the VMP and memory enhancement cues) as a learning tool. To study this, we tested whether it was possible to teach individuals about data privacy compliances using a VE. Also we tested whether these individuals would prefer to use this VE as a replacement to their existing learning methodology.

In our hypothesis, we expected that all participants would show some recall after using the VE. The results from the environment recall test showed that the participants from age groups 21-30 and 31-40 performed the best overall when compared to the other age groups. The age groups 41-50 and 51-60 showed poor overall recall results. A reason of this could be lack of participants in that age group. Another reason could be as the age group increases there is a general lack of visuospatial ability [47] and performance in recall task decreases [53]. Another reason could be that the participants from the age groups 21-30 and 31-40 had a better affinity towards using VR than the other participants. In this study only two participants; one student and one ING employee had prior experience with VR. Their performance in the environment recall test was among the highest. But since there were only two participants with prior VR experience, it was not possible to draw conclusions based on based on experience with VR. An interesting find through the environment recall tests was that even though the placements of the checkpoints in the test were wrong some participants were able to co-relate the positions of the checkpoints that were close together. For example, checkpoints 8 and 9 were placed closer together in the caves when compared with other checkpoints. So, even though in the test they marked the positions of those checkpoints wrong, they marked them close to one another because they were able to remember the guidelines. This was expected as age is a factor when it comes to recall and visuospatial ability tasks [47].

Our hypothesis stated that the VE can be used as a learning tool and help teach individuals (in this study the students from group 2) data privacy compliances who have never worked with these complainces in the past before. So, the first thing we checked was how many guidelines they were able to recall after using the VE. The results were mixed and only about 60% of the students were able to recall with good scores. The students who had poor environment recall scores did have good correlation of the checkpoints as mentioned above. We then checked the final questionnaire scores to corroborate how much information was remembered by the participants after using the VE. From the results, it was found that the students performed similarly to the ING employees (who already had prior experience working with data privacy compliances). Even students with low environment recall scores performed reasonably well when compared to other students. A reason for this could be that the students with low environment recall scores were able to remember and apply the guidelines despite marking the wrong locations for them. The ING employees performed well on the final questionnaire when compared to the environment recall scores. The reason for that could be their prior experience with data privacy compliances led to better performance on the final questionnaire. The low environment recall scores were only noticed with higher age groups. A reason for the low environment recall scores could be the time given (20 minutes) to use the VE might not have been enough to completely grasp all the information. This showed why it was important to test on students as this helped in showing the use of the VE. So, from the results gathered from the final questionnaire and the environment recall scores, with a small number of participants, the lower age groups were able to orientate the VE better than the higher age groups. Also, the VE had a positive effect on learning new information for lower age groups. However, for the higher age groups it is still indecisive whether the effect of VE on learning information was prominent or not.

Further, we investigated whether the VE was engaging and whether it motivated the participants to create a preference of using VE as a learning tool. First we tested the difference of preference of the ING employees between using the VE and already existing ING training exercises about data privacy compliances. From the results we discovered that almost all the tested employees preferred using the VE more when compared to the existing training exercises. Two participants preferred the already existing training exercises because they said that for the information needed to do their job was available through those exercises, and they were satisfied with those exercises. However, nine out of the eleven ING employees did enjoy using the VE and suggested as a replacement for people who work more with data privacy compliances. When we asked students to rate the VE we asked them whether they would prefer to use this method when compared to their normal learning methods. From the results we found that all the students also preferred using the VE when compared to traditional learning methods. The increase in preference from both the groups (students and ING employees) could be based on the unique design of the environment and motivational and engagement techniques. From the participant discussion we can say that most participants enjoyed using the VE some even being too immersed into the VE. A reason could be the use of unique design elements and 3-D sound in the VE. The information in the VE and the VE weren't related and one participant found the colours of the guidelines distracting. This might be a reason for poor performance by some participants in the environment recall test.

Chapter 8

Conclusion and Future Work

This study served as an exploratory research into the memory process, VMP and its uses in daily life situations such as on the workplace, in education, etc. The work presented in this study was motivated by finding the benefits of using a VE in an office to teach employees about data privacy compliances and to justify that the information used by the employees can be taught using the VE by testing on students. This study also showcases the use and effect of memory enhancement techniques in a VE. Our experiment shows that even after a 20 minutes session of using the VE the recall performance of participants was relatively higher at younger age groups. The scores of the final questionnaire for students suggest that the VE was successful in teaching the information stored in it. However, for the ING employees, even with low environment recall scores, their performance on the final questionnaire was slightly better than that of the students. Based on the preference scores it can be concluded that the VE was preferred throughout all the participants with some exceptions. This can be based on the unusual design, exploration elements, immersion and engagement techniques as explained by the participants.

The scope of this study was reduced from the initial design due to the time constraints from the ING participants. They were crucial to the experiment and weren't willing to participate if the experiment was longer than 1 hour. The final experiment design used in this study lacked some comparisons (such as; test the difference in performance of the participants on the final questionnaire using the VE and the participants using the already existing ING training exercises.) and tests that would have made the conclusions stronger and led to more concrete research questions being answered. Designing the VE took longer than expected since there were no designers involved, which led to delays and issues in the experiment design. Additionally, the effect of the VE on the memory process wasn't tested. There were also some problems in finding the relevant literature in psychology and computer science since the study on memory enhancement techniques in VR is relatively less researched. One test that was performed by the participants at the beginning of the experiment which was excluded from the study was the Rey Osterrieth Complex Figure test [54,55]. This test was used in the study to test the participant's visuospatial ability. After the experiment, the performance of the participants on this test and the environment recall test. But the results of this test were removed as it was 2-D test and the VE was 3-D. Furthermore, it did provide a clear comparison to answer the research question.

Even with these results the research question cannot be conclusively answered. Nevertheless, our experiment has laid an important foundation for future research in using VE in daily situations. One suggestion could be using multiple sessions of VE for the participants as it may provide better results for older age groups due to their better performance in recognition tasks [53]. A suggestion could be to use the VE as a VMP by providing extensive training to the participants, so that they get to know the environment well and test the difference in the performances. Another could be increasing interactivity, where each participant could choose the location of where to display which information. This could help in creating a more personalised approach to the VE for the participant. Another suggestion could be testing on different types of environment to check which is suited best for creating an ideal VE for the participant. Another test could be to check the increase in retention if the participant was tested on the information while he/she places it in the VE. We experienced that there was a large amount of interest from the participants to use the VE not just on data privacy compliances but also on other information they wanted to remember. The information gathered from the experiment and the possible improvements suggests that a VE inspired by memory enhancement techniques and the memory process can become an essential component in teaching new information i.e. a learning tool.

Annotated Appendix

Appendix A

Motivation and Overview

VR has evolved drastically in the past few years, enabling it to be used in various research areas, from games to education exercises. With this enhancement, VR has been able to transform desktop environments into immersive virtual experiences. This allows an in-depth explorabilty of these environments, while conducting important research such as improving spatial ability.

Based on the idea of using memory enhancement techniques such as the memory palace in a VR space, a virtual environment (VE) was devised with the focus being data privacy compliance training. The aim was to improve the retention of the data privacy compliances for the employees, by devising a training VR environment. In order to pursue a way to achieve these aims and identify the direction with the most promising potential, many approaches were explored.

Based on the results of the considered literature, the focus was chosen to be on understanding the use of virtual environments (VEs) on retention and recall. How a VE can be used as a learning tool to teach about unfamiliar and familiar topics. Previous studies have shown the effect of VEs in VR on teaching new information and using motivation and engagement techniques in virtual environments to increase preference of replay ability (or replay value).

Motivated by the above, this thesis presents this research to gain further knowledge into this subject:

- **Pre-study: gaining basic knowledge into GDPR compliances and GDPR awareness training** - The main goal was to understand how employees at ING work with GDPR and how this training affects their understanding of them.

- **Main experiment: answering the research questions (Section 5)** - Based on the literature study and earlier findings, we developed and answered the research questions of this thesis via our prepared experiment. Also, included you will find the questionnaires (Appendix D) used.

The majority of the results of this thesis are summarized in the first part of the report. Further comments and additional information on the same are described below.

Appendix B

Research Methods

The first step of the thesis was to understand the research problem. This involved understanding what is GDPR and how is it used at ING. Moreover, gathering information on how the memory palace technique works and what are its uses. The second step was to gather relevant literature to support this thesis, and backup the hypothesis. Furthermore, understanding the previous work done regarding the memory palace, memory and VR was also beneficial to the implementation of the final experiment. The final step was the implementation, where all the information gathered from the literature research was applied.

The first step of the implementation was prototyping of the interactive environment and gathering feedback on it from the colleagues at ING. This was followed by an evaluation and testing of the prototype, followed by a discussion. Based on the input from the evaluation the final environment was developed that became part of the experiment. The final step involved designing the experiment (see Section 5) which was followed by the results which helped in drawing the final conclusions and answer the research question.

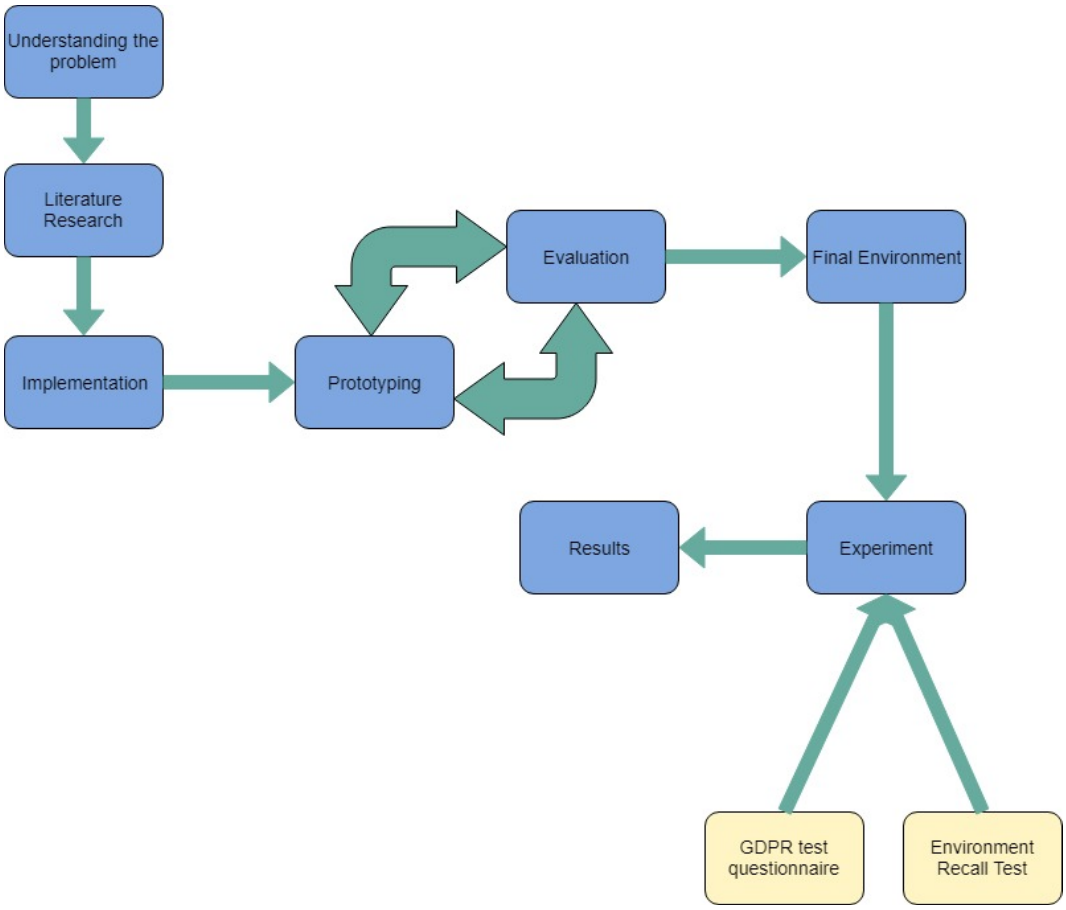

Figure B.1: Research Methods Implementation

Appendix C

Pre-Study: Gaining insight into GDPR

Motivation

GDPR was introduced on 25^{th} May 2018 and due to the addition of new privacy compliances, the implementation of these compliances has been a cumbersome task. These compliances are used by the employees at ING from the GDPR compliance business unit in their daily routine. By using the training exercises devised by ING to teach employees about data privacy compliances, general data privacy guidelines were derived which consolidated these compliances. Furthermore, these guidelines were to be added to the virtual environment (VE) as the information to be remembered using the Method of Loci. After communication with employees from the BU DPE Office (See Figure D.2), a lot of internal company information regarding GDPR was shared using internal links. Therefore, this pre-study explains about GDPR regualtions, how they are implemented at ING and how the employees that use them are trained about it.

C.1 What is General Data Protection Regulation (GDPR)?

The EU General Data Protection Regulation (GDPR) implemented on May 2018 replaces the Data Protection Directive 95/46/EC and is designed to harmonize data privacy laws across Europe, to protect and empower all EU citizens data privacy and to reshape the way organizations across the region approach data privacy.

Customers will have more control as they are better informed of why and when companies are processing their data and can exercise their individual rights based on this.The GDPR replaces the previous data protection directive that regulates the way people's personal data is processed

By processing, it means collecting, storing, using, sending and deleting data, which might belong to customers, employees or suppliers. This data includes information about customers' transactions, their contact information, copies of their passports etc. Customers need to be able to trust the organization to handle that data with care.

Fines can be imposed if these data privacy and protection rules are breached. These figures are higher than ever before - up to 4% of a company's global turnover per event, which could be as much as €650 million based on 2016 figures (figures exclusive to ING). The figure C.1 below gives a general overview on what changes the GDPR compliances [30] have instituted.

Figure C.1: GDPR simplified by ING

C.2 How is GDPR implemented at ING ?

The way GDPR is implemented is different for every company, however, the compliances applied are the same. At ING, (See Figure C.2) the roles are divided from the general overview of the GDPR compliances to the person responsible for processing the company data. However, to keep the scope of the project manageable the focus was maintained on the BU DPE office. The figure C.2 shows the split of the roles at ING on how GDPR is implemented at ING. Moreover, the figure C.3 shows on how the communication works with the DPE and DPO offices. The information provided below is just to show how broad the use of the GDPR compliances extend. Furthermore, it also provides an overview on how the flow of information works when there is a need to use these compliances. This is relevant because it shows how many times the employees from the BU DPE office are contacted during any GDPR compliance situation.

	First Line of Defense	Second Line of Defense
GDPP compliance Overall	**Bank DPE (Data Protection Executive)** Accountable for compliance with and implementation of the GDPP within ING globally.	**Bank DPO (Data Protection Officer)** Responsible for interpretation of the policy, advice and supervising compliance with the GDPP within ING global.
	Bank DPE Office On behalf of the Bank DPE performing the (coordinating) activities for compliance with and implementation of the GDPP.	**Bank DPO Office** On behalf of the Bank DPO performing the activities re. policy, advice and supervising compliance GDPP.
GDPP Compliance Business Unit	**BU DPE** Accountable for compliance with and implementation of the GDPP within the business unit.	**BU DPO** Responsible for providing advice to BU DPE and supervising compliance with the GDPP within the business unit.
	BU DPE Office Performs operational activities relating to the compliance of GDPP commissioned by the BU DPE and the CDO.	
Personal Data Management	**CDO (Chief Data Officer)** Responsible for setting up the data mgt. strategy and data governance and accountable coordinating with the Data Owners within the BU.	
	Data Owner* Responsible for managing data during its lifecycle, including Data Access, Data Lineage and archiving/deletion.	

*) The data owner can delegate specific tasks to the data steward. In most cases, the data owner is also the process owner.

**) Personal data management is part of data management.

Figure C.2: Data Protection Management Roles and Hierarchy [31]

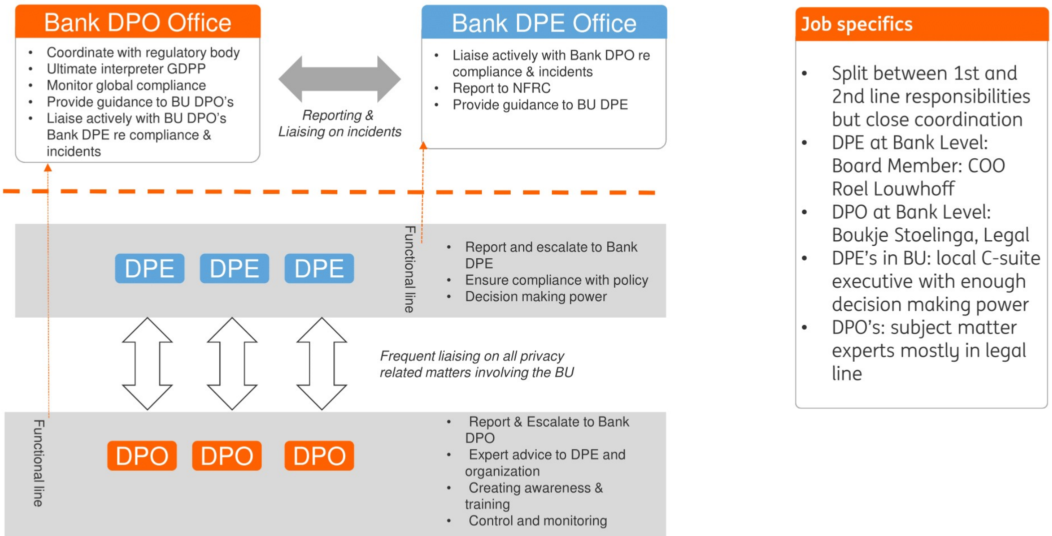

Figure C.3: Communication between management responsible for the Data protection compliances at ING [31]

C.3 GDPR awareness training

Even before the implementation of the GDPR compliances, ING was very cautious about customer privacy and general privacy statements. Specifically, the BU DPE office deals with data privacy situations on a daily basis, out of which most them correspond to customers. Naturally, the employees have to be trained to handle these situations keeping in mind the privacy compliances. So, to aid their training ING introduced E-learning exercise for every employee that joins ING.

The training exercises [32] that are used talk about Personal Data, Cyber-Security, Compliance Induction and many more general workplace compliances. These e-learning training exercises involve going through a set of questions, where each question is a different situation (See figure C.4) that an employee in the company would face. The questions are multiple choice and the right or wrong answer is provided with an explanation (See Figures C.5, C.6). Moreover, the exercises also provide general information about the topic of the exercise. Since, GDPR was instituted, it changed the way how a customer data is processed in the workplace, and gave them more control over their data. So, to educate the BU DPE office a few seminars were held and brochures (figure pending) were distributed that explained how GDPR would effect the employees working in the Data protection area.

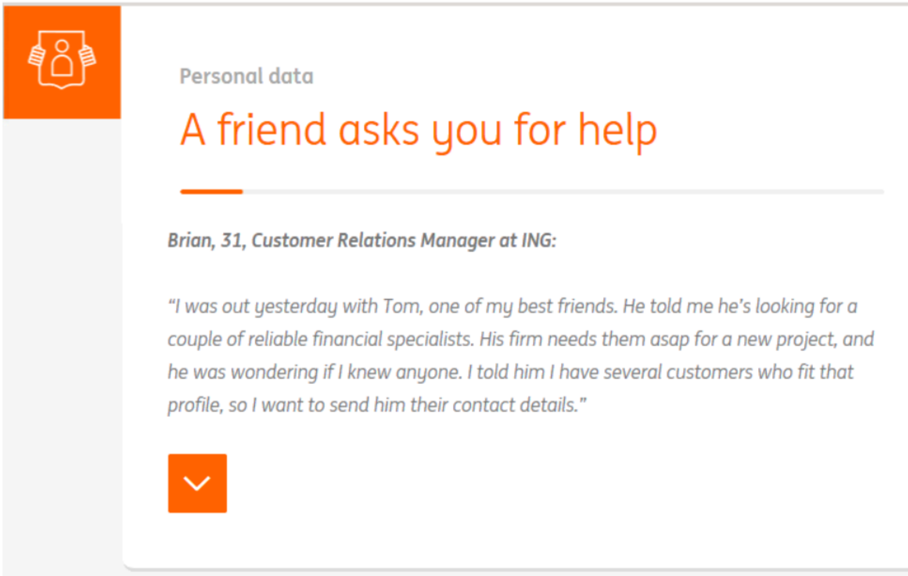

Figure C.4: Basic information of the case study

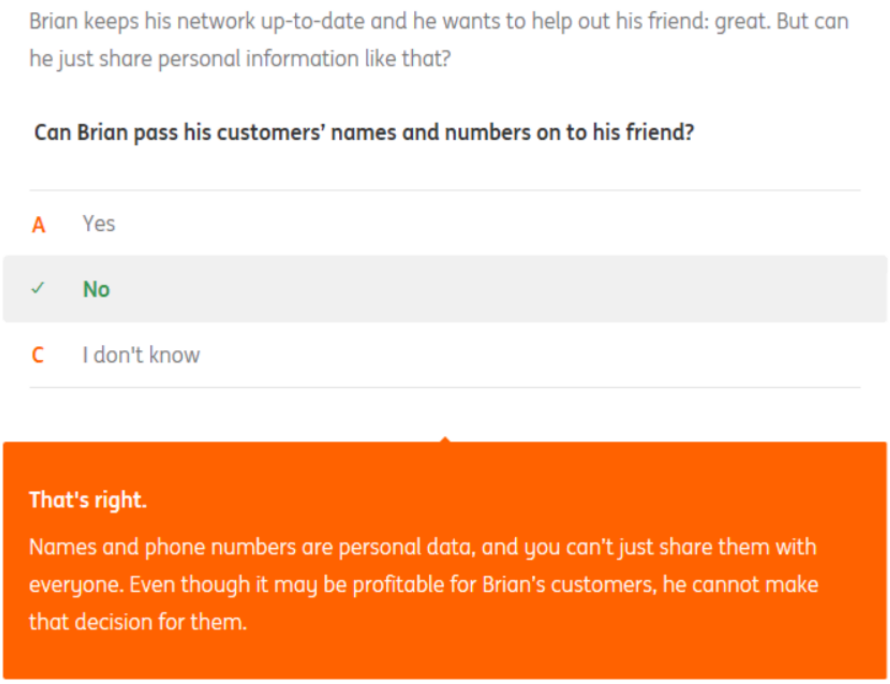

Figure C.5: If the answer is right

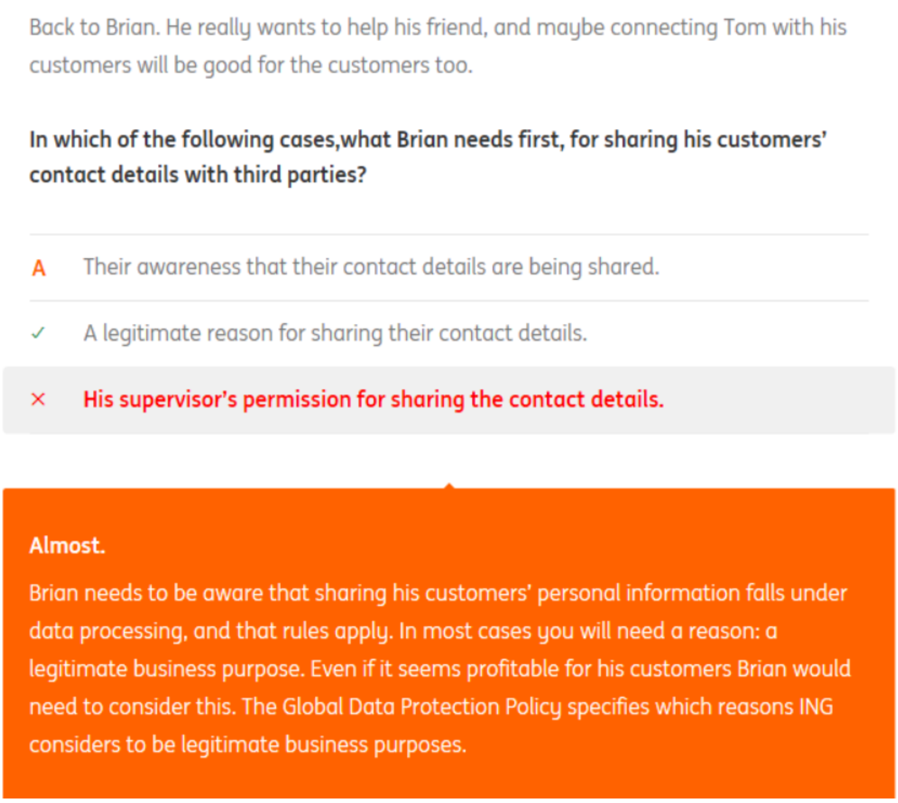

Figure C.6: If the answer is wrong

The employees at BU DPE office don't have to physically remember the compliances as stated in C.1, but more importantly, how these compliances should be applied to deal with day-to-day privacy related situations. Moreover, not only do the employees have to understand these compliances, but also have to translate them for the customers. They do this by writing a broad privacy statement [33] in collaboration with the legal team, where they explain how customer data is processed, how customer rights over their data work and how their data is protected.

Understanding the use of these compliances at BU DPE office was crucial for this project. This provides us with the insight on how employees at ING deal with the GDPR compliances and how they apply them to daily situations. The references provided in the pre-study are private and require access from ING to view them for further information.

It is important to note that the links used from ING cannot be accessed without the permission of the author or the contact person at ING namely; Dr. Joost Bosman.

Appendix D

Questionnaires and Tests

D.1 Environment Recall Test

This test was provided to the participant after finishing the Sudoku puzzle where the light blue markers in the figure D.3 and the colored markers in figure D.4 represent the location of the checkpoints as seen in the environment. The design of the cave system was made slightly complex to confuse and test the participants. The participants were asked to mark the number of each checkpoint they visited in the environment. Each correctly marked checkpoint got 1 point and 0 for incorrect with a maximum score of 10. But, even in incorrect markings the correlation between the incorrectly marked checkpoints were noted.

Name: ____________________________

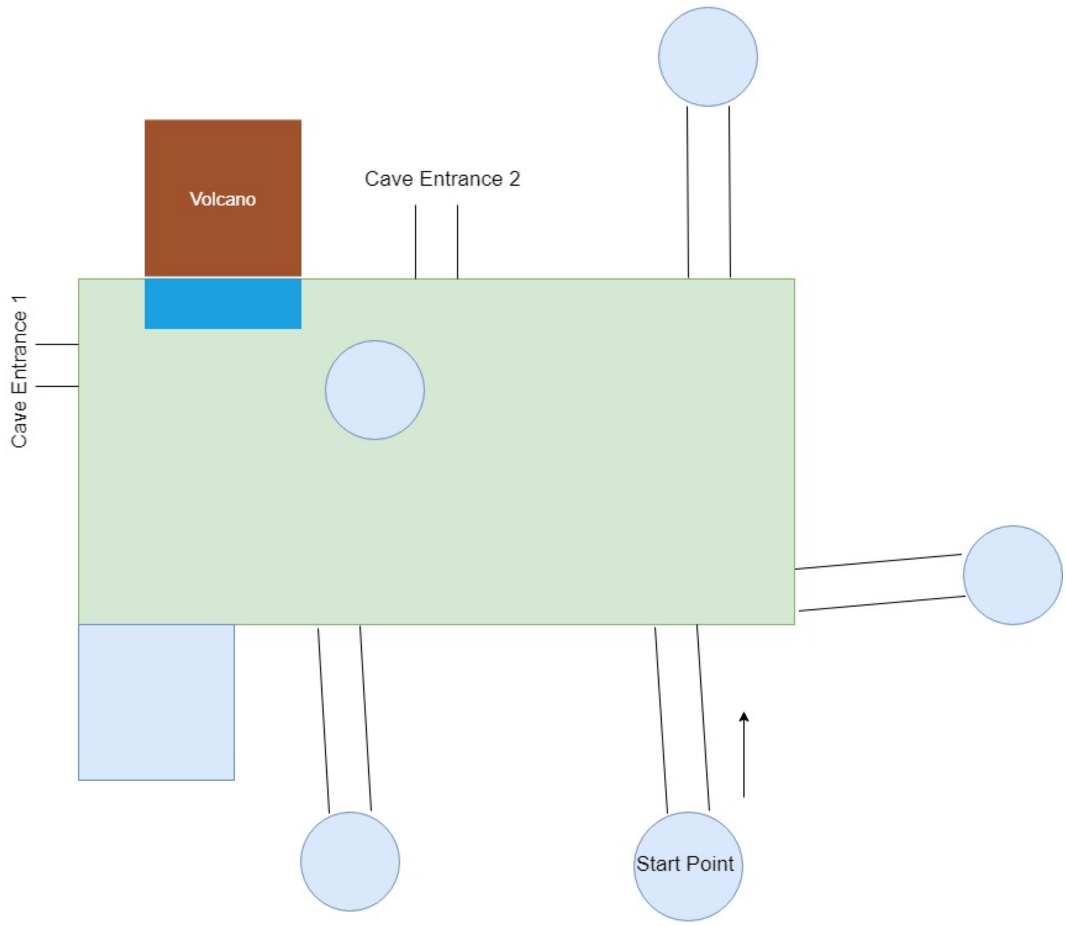

Figure D.1: Outline of the top of the island

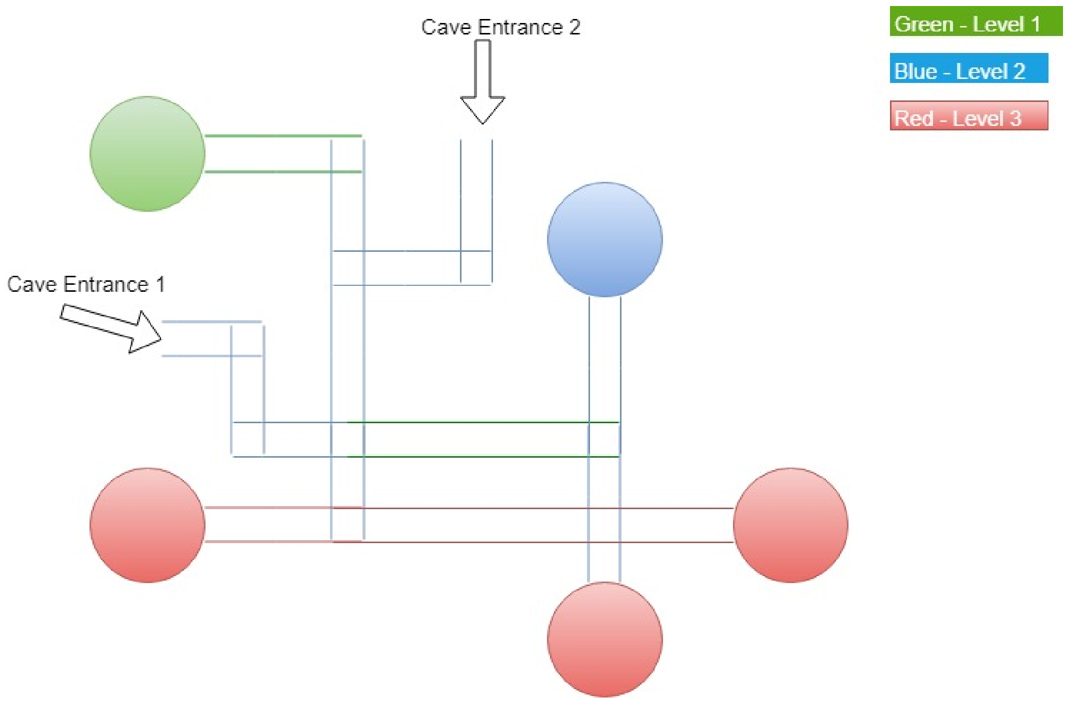

Figure D.2: Outline of the cave system on the island

D.2 Final Test Questionnaire

This test consists of 14 questions that are linked to the application of the 10 guidelines used in the experiment. This test helped in determining how much information the participant was able to remember and understand from using the environment. The question types varied from direct questions (number VII) to situational questions (VIII) derived from the 10 guidelines used in the study. Each question carried 1 point for correct, 0.5 for partially correct and 0 for incorrect. Each sub question carried 0.5 for correct and 0 for incorrect. The maximum score of this test was 14.

Questionnaire after the experiment

Name: __________________________

I. Daisy is an employee at ING working in customer relations. Her friend Alex needs some help in his firm and asks daisy if she could share some information about her customers who are financial experts.

1. Do you think it's okay for Daisy should to share their information with them? (Tick your choice)
   a. Yes
   b. No

2. If you answered "Yes" to the previous question, please describe why and if you answered "No" to the previous question please specify when it would be a good reason for Daisy to share that information or not share it at all. (Answer in 2-3 lines or less)

II. What types of personal data do you think comes under personal data that is handled by ING on a weekly basis? (Multiple answers possible)

a. Names/surnames
b. Addresses
c. Dates of birth
d. Phone numbers
e. Email addresses
f. Gender Passports (or passport copies)
g. Fingerprints
h. Social security numbers
i. Bank account numbers
j. Customer contract numbers
k. Salaries

l. Monthly deposits combined with bank account details
m. Business names
n. Names of major shareholders of a company

III. Jack (a new client) attended an ING network lunch and registered in the mailing list for future offer. In the email he received from ING he realised that his name was misspelt. So, what should he do?

a. Contact the person mentioned in the privacy statement.
b. Visit the office with identification.
c. Call the ING service desk
d. No way to edit his name.

IV. Which of the following scenario/scenarios describe a legitimate business purpose, do you think? (Multiple answers possible)

a. To execute an agreement, personal data of the concerned individual is processed as long as enlightening the person.
b. For an internal audit, several files with customer information are checked.
c. Results from the customer satisfaction questionnaires are collected and sent to the marketing department.

V. In which of these cases do you think personal data is used for another original legitimate business purpose? (Multiple answers possible)

a. When closing a bank account, the relevant documents are transferred into an archive.
b. For an internal audit, customers' personal data are investigated.
c. A prospective customer fills in her contact details at the service desk to be contacted again later.

VI. Tim (Data Analyst) wants to plan a local survey to see how much money parents save up for their children for their college education. After the survey Tim finds interesting results and wants to contact the parents about the results he found.

1. What should he keep in mind before he contacts them? (Multiple answers possible)

   a. Nothing in particular.
   b. The participants may not need his advice.
   c. Some participants may have indicated they don't want offers.
   d. Local law may require that ING asks for prior consent.

2. Tim would like to post the results on the ING blog but is unsure of how to do it. So, he asks the data protection officer. What do you think he/she will tell him?

   a. That he can use the data, because his purpose for using it is clear.
   b. That he can only use statistical information, no names or other identifiers.

VII. What's the most important difference within anonymisation and using pseudonymity?

a. If you use pseudonymised data you can't do whatever you want with it; with anonymised data you are not restricted by data protection laws.
b. If you use pseudonymised data you have to know a lot about encryption; with anonymised data there's no need for that.
c. If you use pseudonymised data you can still trace the information back to the individual; with anonymised data you can't.

VIII. Caterina (works at HR) wants to know if and how salary scales affect employees' job satisfaction on the work floor. She wants to ask participants the following data: age range (20-24, 25-29, etc.), salary scale, ING location code. However, some people might find it uncomfortable to participate. Why do you think using these criteria might be a problem?

a. Because no one wants to talk about their salary.
b. Because ING location code is too specific.
c. Because age range is way too general.

IX. According to you, which of the following data examples also classify as sensitive? (Multiple answers possible)

a. Ethnic origin
b. Political opinion
c. Birth date
d. Health record
e. Bank account number
f. Relationship status
g. Address
h. Religious beliefs

X. Josh (a small business advisor) receives an email from his client containing copies of the passport belonging to the client. However, Josh did not ask for the information, moreover, there is no need for those documents at this point of the transaction. What should Josh do? (Multiple answers possible)

a. He could keep the copies in his inbox for a while; just until the brothers have decided.
b. He could delete the copies securely; if they come by he can always ask for their ID again.
c. He could archive the copies; this way he can use them when he needs to.
d. He could contact the brothers to ask them if he can hold on to the passport copies until they have decided.

XI. Joab (Marketing executive) forgot his company laptop in the train. What do you think he should do? (Multiple answers possible)

a. Wait until Monday and check with my colleagues.
b. Call and report the incident to the police.
c. Look around, maybe someone saw something or found my laptop.
d. Report the loss to my manager.

XII. If a data breach occurs at ING what do you think the consequences could be? (Multiple answers possible)

a. The negative publicity harms the reputation of ING.
b. ING receives an expensive fine for failing (security) regulations.
c. The client, which the data belongs to, might leave ING.
d. It triggers investigations into ING’s compliance with data security regulations.
e. It could decrease ING's competitive ability.

XIII. Which of the following scenarios do you think comply with security requirements? (Multiple answers possible)

a. You use your colleague’s password and ID to log in.
b. During the break in a meeting with customers, you leave your closed laptop in the (locked) meeting room.
c. Your boss keeps his hard drive with clients’ contact information in an open cabinet at home.
d. You find your colleague’s encrypted UBS stick on a desk in an open office.

XIV. Karen (customer) wanted to check on how much information ING had about her, so she contacted the ING for the information. What options do you think she has?

a. She can request corrections or updates, if needed.
b. She can request deletion of certain information.
c. She can choose to do a check like this occasionally.
d. She can object to receiving ING news and offers.

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